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A SOIL RUNOFF EXPERIMENT

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Whenever a resource has been exploited in the past in our country, the local citizenry or its representatives have usually come to the rescue of the resource. Laws have been enacted to halt further exploitation. A decade ago few individuals would have thought possible a law to control the use of waterways and the extent of their pollution. However such laws have been enacted in New York State. Exploitation of soil, the basic resource, is in evidence in any state in the nation. If this drain on the nation's basic resource continues, is it not possible that legislation to control the utilization of this resource might be forthcoming? Who can better bring pressure for such reform, if and when it is needed, than an enlightened public? More important than legislation to forbid further exploitation is education in wiser use of the resource. This is particularly true in the case of soils. We might well take heed of the old proverb, "A stitch in time saves nine." Where is there a better place to take "the first stitch" than in our schools? After all here in the schools are the individuals who will, in a matter of a few years, be in a position to make the decisions as to whether our resources will be utilized wisely or expended unwisely. What then can we, as public school teachers, do about it?

Let us consider one phase of soil management; namely the control of runoff. We might talk about it and recite numerous lists of available data to show that cover on the soil has a marked effect on runoff. We could show movies to illustrate our point. We might even set up "earth study pans" in our rooms and demonstrate artificially the runoff from bare and covered slopes. However these methods are all substitutes for the real thing. A much more effective way of demon-

strating runoff from bare and covered slopes is possible. The only equipment needed is galvanized sheet iron, stove bolts, a shovel, liquid solder, tin shears, some old lumber, and containers with a capacity of at least 5 gallons. In addition to those materials, we must, of course, have a slope on which to conduct our experiment.

The runoff funnels which are used in the experiment are constructed of light weight (28 gauge or less) galvanized sheet iron. Patterns for their construction are included as Figures 1 and 2. A diagram of the completed funnel is shown in Figure 3. It is simplest to work with galvanized sheet iron which is usually available from local hardware stores. However if this source of supply is not available, one might procure galvanized sheet iron from roofs of old buildings which are being torn down. In one case it was possible to purchase sheets of 3′×8′ metal. The runoff funnels were constructed from three of these sheets.

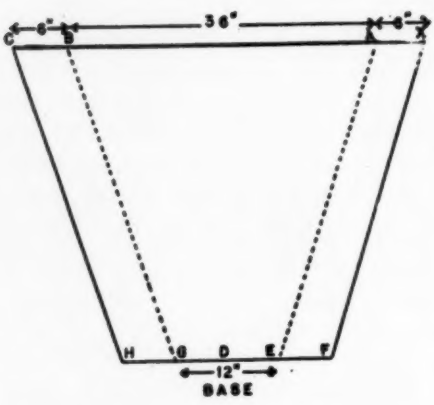

FIG. 1. Diagram-pattern for frame of runoff funnel.

FIG. 2. Diagram-pattern for frame of runoff funnel.

The dimensions of the base of the funnel were laid out on one sheet of 3′×8′ galvanized iron. A mark was made with glass marking pencil 6″ from the edge (*X*) of the longer side of the sheet. (For location of points referred to in this discussion see diagram, Figure 1.) Let us call this point (*A*). A second mark on the long side was made at a point 36″ from (*A*). Let us refer to this point as (*B*). A third point was located 6″ beyond (*B*) and is designated as point (*C*). On the opposite edge of the sheet a point was located 18″ from the edge. This point (*D*) became the center of the base of the mouth of the funnel. To the right of this point at a distance of 6″ from (*D*) another point (*E*) was placed. Six inches to the right of (*E*) another point (*F*) was made with the marking pencil. Two more points, (*G*) and (*H*), were laid out to the left of (*D*); (*G*) being 6″ from (*D*) and (*H*) at a location 12″ from

(*D*). Lines were then drawn connecting *X* and *F*, *A* and *E*, *B* and *G*, and *C* and *H*. These lines form the pattern for the base of the runoff funnel. Tin shears were used to make cuts along lines *XF* and *CH* Next the sides *CBGH* and *AEFX* were each bent up so that they were perpendicular to the trapezoid, *BGEA*. The line *EG* then became the base of the mouth of the completed funnel, and the line *AB* became the base of the opposite open end.

The top of the funnel (see Figure 2) was laid out and constructed in a similar manner except for one change. The perpendicular sides of the top were 1″ wide instead of 6″ wide.

The base of the funnel was made more secure by including two

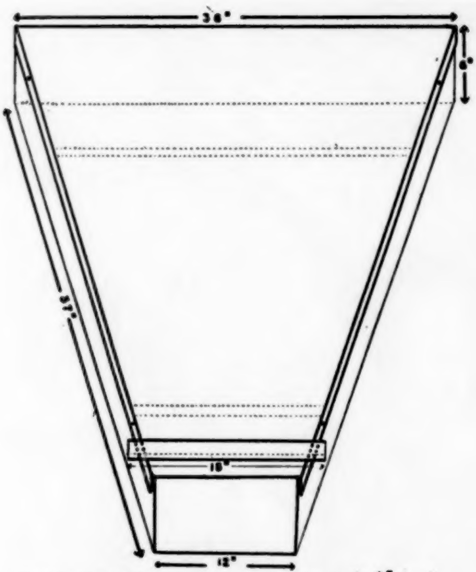

FIG. 3

wooden cross-pieces between *CH* and *XF*. The two sides of the base were nailed to these two cross-pieces. These cross-pieces also served as support for the top of the funnel. The top of the funnel was attached to the base with stove bolts. These stove bolts were inserted through holes punched in the vertical edges of both the top and vertical sides of the base. Two bolts were used on each edge. It is necessary to construct two such funnels if one is to compare the amount of runoff from a covered slope and from a bare slope.

The funnels were put in place at the foot of the slope and cuts outlining the border of the base were made in the soil. Beneath the area of emplacement of the funnels, the sod and soil were removed to a depth of approximately 4″. This left a vertical cut in the soil against

which the larger open end of the funnel could be placed. If the soil is particularly stony, additional procedures must be carried out. In this case it will be found that the larger open end of the funnel does not rest against the exposed vertical soil cut. To alleviate this difficulty the funnel is removed and a strip of galvanized sheet iron 3″×36″, is driven into the lower edge of the vertical cut. This strip then acts as a baffle plate under which the base of the funnel is inserted. Funnels are kept in place securely by wires attached from each upper edge of the funnel to stakes driven in the ground up the slope.

In the case described here a five-gallon crock was placed in a pit

FIG. 4. Runoff funnels with protective "roofs" removed. Note eaves troughs on upper surface of funnels which divert water away from the catch crocks.

which had been dug in the region of the smaller open end of the funnel. This crock served to collect the runoff. (For complete set up of runoff experimental plots, see photographs, Figures 4 and 5.) To prevent collection of rainwater which might fall directly into the collecting crock and therefore be considered as runoff, a roof, made of galvanized sheet iron was placed over the crock. (See photograph, Figure 5.) Since the upper surface of the runoff funnel might also act as an avenue for water runoff into the crock, an "eaves trough" was soldered in place on the upper surface of the funnel. This "eaves trough" was constructed as follows: a strip of galvanized iron, 3″× 16″, was cut. A line parallel to its length was drawn 1″ from one long edge. This 1″ strip was bent so as to be perpendicular to the remain-

ing 2″ of the original strip. In this way, two surfaces were made; one which was 1″×16″ and the other which was 2″×16″. The 1″×16″ surface was soldered in place on the upper surface of the runoff funnel. It was placed parallel to the lower open end of the funnel and at a distance of 3″ from the edge of this open end. This "eaves trough" then served to direct water running down the upper surface of the funnel away from the catch crock.

In the particular case described here, two runoff funnels were put in place. Each of the runoff plots were fenced in to limit the area from which runoff might be recorded. To accomplish this 3″ wide strips of

FIG. 5. Runoff plots showing crocks with protective covers in place.

galvanized sheet iron were driven into the soil to a depth of 3″ along the margin of each runoff plot. By this method then, runoff was limited to that from within the confines of the metal strips. The area of each runoff plot was 18 square feet, being 3′×6′. The vegetation on one of the experimental plots was removed while that on the second plot was not disturbed.

Some interesting data have been collected from the two plots described above. During the period August 30, 1950 through September 1, 1950 in the vicinity of Ithaca, New York, 4″ of rainfall fell on these two plots. The runoff from each of the plots was collected

and filtered through absorbent cotton. The results show that from this rainfall 25 quarts of liquid containing 255.8 grams of solids were collected from the bare plot while 3.15 quarts and 3.1 grams were the corresponding figures for the covered plot. During the period between September 10 and 16, 1950 at the same location, there was recorded $3\frac{1}{2}''$ of rainfall. In this case 7.25 quarts of liquid and 10.4 grams of

A B

Runoff collected after rain which continued over the period, August 30, 1950 through September 1, 1950. Rain was a combination of a steady downpour and a cloudburst. Total rainfall—4″.

A—from covered plot	B—from bare plot
Volume of liquid—3.25 qt.	Volume of liquid—25 qt.
Weight of filterable solids—3.1 gm.	Weight of filterable solids—255.8 gm.

A B

Runoff collected after rain which continued over the period, September 10 through September 16, 1950. Rainfall was almost continuous and amounted to $3\frac{1}{2}''$.

A—from covered plot	B—from bare plot
Volume of liquid—0.5 qt.	Volume of liquid—7.25 qt.
Weight of filterable solids—0.5 gm.	Weight of filterable solids—10.4 gm.

Fig. 6

filterable solids were collected from the bare plot while 0.5 quarts of liquid and 0.5 grams of solids were collected from the covered plot. (See photographs above, Figure 6.)

Here then is an activity which demonstrates the value of cover on the land. The demonstration is not one carried out in artificial sur-

roundings but is done using the resource itself in its natural setting. Perhaps this and similar experiences with soil might give the student a better knowledge of and appreciation for his basic resource. With knowledge should come understanding while with better understanding should come wiser utilization of the resource. Wiser utilization of the resource would make unnecessary the enactment of compulsory legislation which usually follows exploitation. Perhaps here is an example of the American way of doing things.

BIRD FILMS

A new series of motion pictures illustrating phases of the life and habits of a variety of North American birds has been released by Encyclopaedia Britannica Films. The series consists of four films, three under the general title of BIRDS OF NORTH AMERICA and the fourth BIRDS OF THE SEASHORE.

All four films are 16 mm full-color educational sound films and were produced by the National Film Board of Canada in cooperation with the Dominion Wildlife Service, Department of Mines and Resources. The series is designed to supplement textbook material on the study of birds and to develop interest in ornithology among young people. These four films show identifying features of many different birds and explain habits of nesting, feeding, protection of the young and ways in which birds are helpful to man. Closely related to such EB Films as WATER BIRDS, BIRDS ARE INTERESTING, ROBIN REDBREAST and BIRDS OF PREY, these four films are intended for middle grades science and language arts classes and for adult groups.

The first of the three films on BIRDS OF NORTH AMERICA shows three birds; the killdeer plover, the nighthawk, and the cedar waxwing. Characteristic markings of these birds and their familiar cries are illustrated. Animated maps point out summer and winter habitats, and by means of close-up photography feeding habits of the young birds are portrayed.

In the second of this group, three more birds are seen; the spotted sandpiper, the sora rail, and the Barrow's golden-eye. The mother birds on their nests, the eggs hatching, and the young birds venturing out into their world of rock, reed and water are shown in sequence.

The third in the trio depicts in full-color the yellow-shafted flicker, the chestnut-sided warbler, and the mountain bluebird. Nest-side views of the activities, development, and habitats of these birds are illustrated and, as in the first two films, distinctive markings of the birds are seen and animated drawings reveal where each of them may be found.

BIRDS OF THE SEASHORE shows such birds as the blue heron, razor-billed auk, cormorant, black guillemot, eider duck, gull and gannet. Authentic bird calls are heard throughout the film. The eider ducks were filmed on the islands of the St. Lawrence estuary where they breed unmolested by human beings. A colony of gannets, summering at Bonaventure Island, are shown as they dive for fish for their dinner, and a crowded colony of gulls are shown competing for nesting sites at the beginning of the breeding season.

BIRDS OF NORTH AMERICA, Number 3, Number 4 and Number 5 and BIRDS OF THE SEASHORE have a running time of ten minutes each. They may be purchased for $100 each from Encyclopaedia Britannica Films, Wilmette, Illinois, or from any of eight branch offices in New York; Boston; Birmingham, Michigan; Atlanta; Portland; Dallas; Chicago and Los Angeles. These films may be rented for $4.00 for one to three days' use and 50¢ per day thereafter.

EFFECTIVENESS OF SOUND MOTION PICTURES IN TEACHING A UNIT ON SULFUR IN HIGH SCHOOL CHEMISTRY

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Present research in the field of audio-visual education indicates that instructional motion pictures have a genuine value in teaching, but that their effectiveness depends upon the clarity of purpose for which they are used. Also, the type of material being studied, type of students, character of the films used, the methods of projection and use, and influence of the teacher who uses the films all affect the efficiency of the end results.

During March, 1951, a study was carried out at the Township High School, Rochelle, Illinois, to determine if the proper use of sound motion pictures would have a significant effect on the achievement of high school chemistry students. One class of students was taught a unit on sulfur as effectively as possible in the usual manner, and at the same time a second class was taught the same material in the same manner, with the one exception that several carefully selected sound films were used according to recognized techniques. All students spent the same amount of class time, in this case seventeen days, on the material covered. Students repeating the course, transfer students, and students in the film group who were absent when the films were shown were omitted from the study.

Since audio-visual educators now realize that a film is not a substitute for the teacher but only an aid to him, and that excellent teaching films lose much of their value when not presented properly, every effort was made to present the films in the most effective manner. One film, which was used to introduce the unit to the film group, was entitled "Sulphur." It was a technicolor sound film distributed by the United States Bureau of Mines. In twenty-two minutes the film gave an over-all view of the sulfur industry and was particularly thorough in explaining the Frasch process for modern sulfur mining.

A second film, which was used on the eighth day of the unit, was a twelve-minute Coronet instructional film entitled "Sulphur and Its Compounds." Most of the film was devoted to a thorough exposition of the physical and chemical properties of sulfur and its valuable compounds. The laboratory preparation of the allotropic forms of the element was shown and the film ended with brief mention of life-saving sulfa drugs. This second film correlated closely with the part of the unit being studied at the time of use, and was therefore used as a direct instructional device.

During the last double period of the unit both films were shown for the second time. In this case they were shown as a means of reviewing some of the important features of the unit. Since the students were then familiar with the films, only a few minutes were taken in advance to explain the purpose of showing the films again.

With the exception of the days on which the films were used, the treatment of the non-film group was the same as for the film group. The same instructor taught both classes, the same material was covered, and in general the same techniques were used throughout. However, on the three days that the films were shown to the film group the non-film group was given exercises that were purposely chosen to elaborate upon materials covered in the discussion periods. The exercises required the students to write answers to pertinent questions concerning the unit. The time spent on the exercises was equally divided between answering the questions and discussing the answers.

At the completion of the unit a comprehensive objective examination was given to both groups at the same time. Exactly five weeks later the same test was again given to both groups at the same time and in such a way that it was completely unexpected. The element of surprise was obtained by giving the retest at the completion of another unit. After the test was given the first time the answers were discussed in both classes at the next regular meetings. However, the students were not allowed to keep either the test questions or the answer sheets and had no further contact with the test until it was given the second time.

The test and retest data were treated statistically by the analysis of covariance for significance in the three areas of "Achievement at End of Unit," "Retest Achievement," and "Retention Loss." Since individual differences in ability and aptitude were known to exist among the students, three independent variables were chosen as controls to remove the possible bias introduced by these differences. The controls chosen for this study were: (1) Total grade points in five common courses taken during the freshman and sophomore years, (2) I.Q. from the California Mental Maturity Test, and (3) Scores accumulated on previous chemistry tests. The effectiveness of the controls selected was shown by the coefficients of multiple correlation between each criterion and the controls. The coefficient of multiple correlation between unit test scores and a combination of the three variables was 0.8296, between retest scores and controls the correlation was 0.8307, and between retention loss and controls the value was 0.3431.

A comparison of the film group with the non-film group for both criterion and controls is shown in Table 1.

TABLE 1. MEANS OF TEST SCORES, RETENTION LOSS, AND CONTROL SCORES

	Film Group	Non-Film Group
Number of students	22	17
Mean of end chemistry test scores	82.50	77.82
Mean of retest scores	78.59	73.53
Mean of retention loss	3.91	4.29
Mean of grade point total in common courses	22.59	21.70
Mean of intelligence quotient	106.45	108.58
Mean of scores on previous chemistry tests	17.86	18.11

The statistical treatment of the data resulted in the subsequent F-values: for end test $F_{1,34}=10.53$, for retest $F_{1,34}=7.16$, and for retention loss $F_{1,34}=0.0399$. The first two F-values are significant, but the one in the retention loss area is not. Insofar as the previously mentioned independent variables control the known differences in ability and aptitude, and no other pertinent factor related to achievement in a high school unit on sulfur contributes a bias, the results were interpreted in this manner: the proper use of films increased the effectiveness of teaching the unit when achievement was evaluated at the end of the unit and also when evaluated by a retest, but no significant difference could be shown when evaluated in terms of retention loss.

Therefore, to the degree that achievement has been satisfactorily evaluated in the Rochelle study, the usefulness of sound films in teaching a unit on sulfur in high school chemistry has been demonstrated.

OUR MILKY WAY GALAXY

Our Milky Way galaxy of millions of stars is a giant among the starry universes, Dr. Thornton Page of Yerkes Observatory has just reported to the Smithsonian Institution.

The galaxy of which our solar system forms a tiny part weighs about as much as 200 billion suns, Dr. Page estimates. The Andromeda nebula, nearest object in space beyond the Milky Way galaxy, appears to weigh as much as 100 billion suns. But other nebulae sufficiently close to be seen with the world's largest telescopes weigh only as much as one to ten billion suns, the Yerkes astronomer calculates.

About half the weight of each "island universe" is believed due to the gases and cosmic dust between the stars rather than to the stars themselves.

Latest sampling counts indicate that about 2,000 such starry universes of different shapes and sizes are near enough to our solar system for their light, traveling 186000 miles a second, to reach us within 13,000 years. There are approximately 9,000,000 such stellar universes near enough for their light to have started on its way to use not more than 200,000,000 years ago. As many as 70,000,000 starry universes exist within 450,000,000 light years of us.

SCIENCE AND INTERNATIONAL UNDERSTANDING*

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It is sometimes intimated that teachers, generically speaking, pick themselves to pieces so much that they have difficulty in picking up the pieces and piecing them together again. Perhaps the teaching profession has become introspective, but occasional introspection without too much introversion should be valuable. A good teacher is asked many questions and he asks himself and others many questions also.

Why does society support science? What is the social significance of scientific research and science teaching? What does society expect in return for the time, effort, and money devoted to scientific activity? Does society contribute considerable sums of money merely to enable curious people to satisfy their curiosity; does it contribute because it seeks understanding; does it support science so that it may solve practical problems; does it contribute to satisfy personal ambition of career scientists? There is, of course, no one answer; there are many, and they are not necessarily mutually exclusive. After all, there are many kinds of societies, comprising many individuals, and with many varying objectives; accordingly, the relative emphasis placed on different kinds of scientific activity varies with time and place. A progressive society periodically re-examines and re-evaluates science and its importance in relation to other cultural activities.

Science is one of the essential humanizing agencies. "It helps man to understand and modify his environment; it helps him to accomplish more with less effort; it helps him to develop wisdom; it contributes to rational and ethical concepts and conduct; it can contribute to international understanding and to cooperation among peoples. It can contribute to the attainment, maintenance, and enrichment of peace.

"The obligations of science are even greater than its accomplishments. Science must contribute to society as well as to science; it must serve as well as enlighten."[1]

The objectives and values of science are multiple and are not antagonistic to each other. The spirit of inquiry, of experimentation, of research is essential to progress. Curiosity should not be curbed. There are gifted explorers who point the way to new fields of knowledge and understanding. It would be unwise to handicap them by

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[1] U. S. Nat. Comm., *UNESCO News.* July 1951.

prescribing the objects or methods of their search; they have the spirit and the genius of the pioneer. Others may amplify, consolidate, and capitalize the discoveries. Motives and methods may differ, but each group is useful in its own way. Free inquiry is important, but orderly and persistent inquiry also is essential in many fields of science. Science has many facets; it is a part of culture and should need no further justification. But some scientists must assume the responsibility of helping in the solution of urgent human problems, and surely the problem of promoting understanding among peoples and nations is now one of the most baffling and urgent of all human problems.

It would be superfluous to expatiate on the tragedy of war. And it would be impertinent of a natural scientist to presume to analyze all the reasons for tensions between peoples and nations and to prescribe procedures for removing barriers to understanding. Theoretically it should be easy to induce peoples to act intelligently, fairly, and wisely. Every teacher knows, however, that some individuals fail to respond and adjust to people and situations. Reasonable compromise sometimes is difficult, even though it would be reasonable to compromise. Some people have genius for creating misunderstanding and some have genius for misunderstanding. Sometimes it is hard to find even a small area of agreement among individuals. And the difficulty is likely to be even greater among peoples.

Visionaries tend to minimize and cynics to magnify the obstacles to international understanding. The task of creating better understanding is not easy but it should not be impossible. The problem is complex, and, as is true of most complex biological problems, there is no easy solution. Improvement is more likely to result from gradual evolution rather than from sudden and spectacular revolution. Sound education will be more permanently effective than indoctrination and propaganda. Intelligent appreciation of situations is prerequisite to sound concepts and ethical conduct.

Many misunderstandings between peoples are born of ignorance rather than viciousness. And all too often the ignorant are the most vociferous. Knowledge does not necessarily guarantee sympathy, but real sympathy depends on knowledge and understanding, if sympathy connotes "reciprocal liking and understanding arising from community of interests. . . ." The dictionary adds, of course, "community of aims and compatibility of temperaments."

Sufficiently strong community of interests and aims may stimulate cooperation and effect cohesion despite the tendency toward repulsion and dissociation due to temperamental differences.

Does the law of the minimum apply to people and peoples? Are actions often dominated by determination to attain what is most de-

sired at a given time? Certainly nations with antithetic ideas and aims often have cooperated, at least temporarily, when confronted by common needs and common dangers. Is there enough community of interest among peoples to justify the hope that they will learn that collaboration can satisfy wants and ambitions better than contention? What interests and aims do peoples share in common?

Peoples generally share the desire to satisfy primary wants as painlessly as possible. They want food, clothing, shelter; they share the desire for a pleasant and comfortable life, even though the standards of pleasure and comfort vary widely; and most peoples want to enjoy relative immunity from the menace of disease and premature death. Most people are concerned directly and vitally with problems of subsistence and of continued existence. Therefore they have a basis for understanding scientific needs and contributions in these fields.

The United Nations organization has recognized the basic importance of food and health. The Food and Agriculture Organization (FAO); The World Health Organization (WHO); and The United Nations Educational, Scientific, and Cultural Organization (UNESCO) are helping to organize international cooperation in studying common problems and in the dissemination of information for the common good. They need help, because the appreciation of needs and opportunities must be widely diffused. Every student of science should know what "internationalism of science" really means.

Every country already owes a debt of gratitude to many other countries for scientific methods, for plant materials, and for animals that have helped in feeding and clothing its people. The United States is now "exporting" scientific and technical knowledge, skills, and materials. But we should realize how much we owe other countries for what they gave us. Plant explorers of the United States Department of Agriculture have searched the far corners of the Earth for new and better kinds and varieties of crop plants: wheat, oats, barley, rye, sugar beets, soybeans, alfalfa, clovers, and many kinds of fruits and vegetables. Some of our most basic food and feed crops were not only introduced into this country originally but also owe their present productivity to a great extent to imported varieties that were used to improve them.

The names of many varieties of crop plants that we now use in the United States, either for growing directly or for parental material in producing still better varieties, carry the record of their geographical origin: Turkey Red, Crimean, Red Egyptian, Chinese, Kenya, Scotch Fife wheats; Manchuria, Himalaya, Nepal, Abyssinian, Canadian barleys; Swedish Select oats; Manchu soybeans; Kaffir sorghum; Punjab and Argentina flax; and thousands of other useful plants.

The Western Hemisphere has furnished corn, potatoes, cacao, rubber, tobacco and many other kinds of plants to countries of the Eastern Hemisphere. The basic economy of certain agricultural countries is built on imported and improved plants.

Most of our domestic animals in the United States originated in other countries: Holstein-Friesan, Jersey, Guernsey, Brown Swiss, Hereford, Durham, and Aberdeen-Angus cattle for milk and meat; Hampshire, Berkshire, Yorkshire, Danish hogs for pork and lard; Merino, Shropshire, Southdown and many other breeds of sheep for wool and mutton; Percheron, Belgian, Clydesdale horses for work. We have taken freely and we are beginning to reciprocate by giving; but we probably still are debtors. We received the principal breeds ready made; we have produced superior lines within some of the breeds by selection and breeding; and we are producing some new breeds; we have put scientific principles and methods to work on the basic materials and are now beginning to export them.

The cardinal fact is that we in the United States are using basic food and feed materials from all areas of the world. Although justly proud of our technologic and scientific advances in developing a profitable and stable agriculture, reflection on the source of our basic materials, knowledge, and principles evokes humility and gratitude.

Is "Internationalism in Science" an empty phrase? Even we, with all our natural resources, must be deeply grateful that it has not been an empty phrase. And realization of what we owe should make us more willing to give. For we have received more than plants and animals; we have imported scientific knowledge and principles also.

The basic scientific principles on which depend the maintenance of soil productivity, plant and animal improvement by breeding, the control of plant and animal diseases, and the processing of plant and animal products were discovered and developed in many countries. The foundations for knowledge of soil fertility and plant growth were laid by Sénébier of Switzerland, De Saussure of France, Lawes and Gilbert of England, Hellriegel of Germany; the basic principles of genetics, which are basic to plant and animal breeding, were discovered by Mendel, an Austrian monk, and De Vries, a Dutch botanist; Pasteur, Koch, DeBary, Woronin, Kuehn, Millardet, Theobald Smith—French, German, Russian, American, laying the groundwork of facts and principles for controlling diseases of crop plants and domestic animals.

Liebig, the "Father of Agricultural Chemistry," wrote, "Agriculture is, of all industrial pursuits, the richest in facts and the poorest in their comprehension." Written a century ago, the statement may or may not be true today. Certain it is, however, that agriculture furnishes us our daily bread, and certain it is that hunger and want would be

even more widespread in the world today except for the free interchange of the results of research in the sciences that are basic to agriculture. The story of the relation of science and technology to the evolution of agriculture is fascinating, but still more fascinating and significant is the story of discoveries and developments and of the dissemination of principles, techniques, and materials to all who could and would use them. The barriers, where they existed, were ignorance and apathy. One of the greatest barriers to understanding the need of internationalism in problems of subsistence is ignorance and resulting prejudice. Knowledge regarding mutual contributions and common needs of peoples should help cleanse the spirit of suspicion and dislike for those who have helped us and who need our help.

Despite the amazing progress in increasing food production by applications of science and technology, the problem of feeding the world is acute. Population is increasing at a rate that alarms many thoughtful people; the total amount of land remains fixed. It is clear that acre yields must be increased or ways must be found to use presently non-arable lands, if present population trends persist; otherwise still more people will have to hunger. It is equally clear that some countries now have insufficient land and that others have a surplus and that there have been artificial barriers to trade. This is a world-wide problem and can be solved only by international effort. For this reason UNESCO is promoting research, "especially to improve living conditions of mankind."

Much of the research designed to improve living conditions of mankind can best be done by international cooperation; and some must be done on an international scale because the problems themselves transcend national boundaries. This obviously is true of many human diseases, of animal diseases, of many insect pests of crop plants, and of many plant diseases. A plant disease problem will illustrate.

Stem rust of wheat, one of the most destructive of all plant diseases, can destroy millions of acres of wheat in an epidemic year. In a single year it has destroyed wheat that could have furnished bread for more than 100 million people. It is the most dangerous single enemy to the world's wheat supply. And it does not respect international boundaries. Stem rust is caused by a fungus that parasitizes wheat, oats, barley, rye and many wild grasses. It multiplies and reproduces by producing spores of several kinds. On an acre of fairly heavily rusted wheat there are about 50 thousand billion spores about one one-thousandth of an inch long. These microscopic spores are disseminated far and wide by the wind, sometimes over thousands of square miles in a few days. As wheat is grown almost continuously from Central Mexico to the prairies of Canada, a distance of some 2500 miles without barriers to wind movements, the rust becomes a

dangerous wind-borne international traveler and therefore requires international cooperation for its control. There are two principal control methods: the breeding of rust-resistant wheat varieties and the eradication of certain kinds of barberry bushes on which the sexual stage of the fungus develops. This sexual stage is important because the stem rust of wheat comprises numerous parasitic races which can hybridize on the barberry bushes and thus produce new races that may be able to attack hitherto resistant wheat varieties. There has, therefore, been a succession of temporarily resistant varieties, and new ones now are urgently needed.

A new rust menace to North American wheat appeared in 1950. A virulent rust race, found occasionally near barberry bushes in Eastern United States prior to 1950, spread throughout most of the United States and Canada in that year, became widely prevalent in Mexico in 1951, and is now thoroughly established in the principal wheat areas of North America. Plant scientists in Canada, the United States, and Mexico had developed varieties resistant to the rust races that prevailed for more than a decade. But these varieties are completely susceptible to the new race, designated as 15B, and local or regional epidemics already have ruined thousands of acres of wheat. The destruction of individual wheat fields is a tragedy to individual farmers, but the destruction of millions of acres can become a national or international calamity.

Why is international cooperation essential in such a problem as this? There are many reasons. Wheat breeders in each country need to know which races of rust are prevalent in the other countries: a rust race that is prevalent in one is likely eventually to become prevalent in all. New lines of wheat must be widely tested regionally to determine their range of adaptation. If a variety is resistant to rust or other diseases in the United States but susceptible in Mexico, it is essential to learn the reason. Weather affects varieties and their reaction to disease; consequently it is important to test them under a wide range of weather conditions. It is not always possible to predict which varieties used in crosses will give the desired combination of characters. If one breeder makes an unusually lucky combination, the others are saved much time and money if he shares with them. In reality there is rapid exchange of information and materials. When many people work on a problem of this kind, each may make a relatively small contribution; but when all are combined, it becomes a big contribution. Human geneologies are interesting, but the geneology of wheat varieties and those of other crop plants is equally interesting, and in many respects, even more important for international understanding.

The wheat rust problem is only one example of the need and value

of international cooperation. Plant scientists in all the principal wheat-growing countries of the Western Hemisphere are now cooperating to the limit of their abilities and facilities because they have learned the synergistic value of working jointly for their common good and that of their respective countries. There are many other similar epidemic diseases of many crop plants that must be controlled regionally and internationally. It is important that there be wider recognition of this fact and that better facilities be given for cooperation.

Destructive insect pests of crop plants, like grasshoppers, plant lice, leaf hoppers, and many others ignore international boundaries; animal diseases, such as foot and mouth disease, the Newcastle disease of poultry may spread rapidly from one country to another. Cooperative measures are therefore essential for mutual protection. It is a matter of vital concern to all countries to fight human diseases. The existence of certain infectious diseases in one country may menace many countries. International cooperation in the field of public health is now considered as natural and normal in many countries. Subsistence and health—community of interests among peoples. We all need to learn and think more about what the problems are and what it takes to solve them.

"Internationalism of science" has real meaning, not only for the advancement of science and the edification of scientists but also for the alleviation of hunger and suffering of peoples and for their economic well being. The mutual contributions and mutual benefits in other fields of science and technology could serve also as examples of community of interests among peoples. To pass the other sciences without mention is not to disparage them. Subsistence and health are emphasized merely because the largest number of people probably understand them and are directly and vitally concerned with them. This is almost certain to be true of the two thirds of the people of the world who suffer from hunger and disease. But too few of those who suffer, too few people in general realize what debts they already owe to other peoples and what further benefits can be derived from cooperation among peoples and nations. To increase this understanding is one of the obligations of education.

Science has contributed to international understanding; it can and must contribute more if the centripetal forces among peoples are to prevail over the centrifugal tendencies.

Science prides itself on its objectivity and internationalism, but these qualities are not unique to the scientist. The scientist is confronted with the inexorability of facts; he must be objective to learn the truth about phenomena. Many scientists must be international in outlook, because their problems are international in scope. Science

must recognize facts, whether pleasant or unpleasant, whether good or bad. A good scientist must have a "disinterested love of truth"[2] regarding all phenomena, not only about the phenomena of his special field of science. There is no place for prejudice, in the sense of prejudging, in science. The analysis of human problems must be just as objective as the analysis of the phenomena nature. All analyses, principles, and judgments must be based on facts. This is part of the scientific attitude, which is tragically lacking in many of our human relations. The scientific attitude must impel us to try to find out not only how people and peoples act, but also why they act as they do. Only by knowing their problems can we justly commend or condemn. Knowledge is basic to understanding, to sympathy, to justice. Problems must be solved on the basis of knowledge; the method of trial and error usually is too costly.

Does scientific knowledge guarantee ethical conduct? Not necessarily. Sarton writes (loc. cit., p. 143), "What happened to Greece is that the intellectual activities of its people were hopelessly out of proportion to their political wisdom and their morality." Every generation, every nation has the problem of perspective and proportion in its intellectual, aesthetic, and moral life.

How much can science contribute, not only to the solution of problems that contribute to the comforts of civilization but also to those that menace civilization? "Can insistence on a scientific attitude gradually help substitute facts for fancies; principles for prejudices; education for propaganda; intellectual integrity for mental cleverness; statesmanship for partisan politics; broad humanitarianism for tribalism; the Golden Rule for the law of the jungle? Can science help human beings act the part? Can it contribute both to wisdom and to ethical conduct? This should be the ultimate goal of science."[3] And it should be the principal contribution of science to general education.

But we need more than science. "Humanity needs both the sciences and the humanities; both are humanizing to the extent to which they humanize. There is need for more understanding and tolerance between scientists and humanists; properly motivated, all are humanists and their joint contributions can accelerate man's evolution toward intellectual enlightenment and spiritual refinement."[4] And they must contribute to understanding and peace among peoples.

[2] Sarton: *The Life of Science*, p. 145.
[3] *Science*, Vol. 113, No. 2928, Feb. 9, 1951. p. 142.
[4] *Loc. cit.*, p. 142.

Illuminometer, a weather instrument to record the intensity of daylight, has a photocell unit and a recorder that can be placed several hundred feet apart without loss of sensitivity. The cell assembly is designed for mounting on top of a mast; the housing casts no shadows on the receiving surface.

TEACHING FOR APPRECIATION OF MATHEMATICS*

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One of the desired goals of mathematical education, expressed in every significant national report, and in most textbooks, is to develop an "appreciation" of mathematics. The word "appreciation" is seldom defined or explicitly described, and psychological considerations are generally ignored except that somehow appreciation involves the aesthetic and the emotions. We find and hear statements of the nature "If we stress activities and experiences which enlist the heart and soul of childhood and youth, broader and deeper appreciations will result." Just what the "heart" and "soul" of youth are, or how they are enlisted, is not discussed. The statement is just so many empty words. Others say "It will not matter very much what knowledge the children learn in appreciation lessons. But how they feel about these lessons will be of tremendous significance." There is usually added to this statement an expression to the effect that "there should be a clear separation of feeling from the intellectual distraction that comes from speculating about meaning." Thus to persons making such statements, appreciation is to be devoid of meaning and intellectual activity. This paper takes the very anti-thesis of this point of view.

It may be conceded that one can enjoy and appreciate that which is explained by, or which is the outcome of applied mathematics, without actually knowing the mathematics. But this is an appreciation of color, of design, of tone, of architecture, etc., and not of mathematics, and it constitutes an entirely different form of mental structure than that appreciation which comes from the actual knowledge of and search for mathematics. Designs made with rulers and compasses (or other instruments), by curve stitching, by geometrical cut-outs and models, are all nice to look at, and give a sense of satisfaction, even emotional pleasure, and they can aid as means of motivation to, but they are not in themselves an appreciation of mathematics.

The appreciation of mathematics comes when we seek it and use it as a means of explaining our environment, explaining design, and so on. It is also a search for and extension of abstract logical structures as satisfying mental creations. It is the purpose here to investigate briefly the nature of appreciation of mathematics, and to illustrate this genuine appreciation with some forms of elementary mathe-

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matics. To rigorously define appreciation as a psychological construct is very difficult. It is easier to first state some of the essential elements entering into appreciation, some of the reactions that accompany it, and then define or illustrate it.

First, let us note that there are levels of appreciation in mathematics as well as in the arts. To recognize the relations in a multiplication table, to know how this table enters into indispensible daily activities, and to see it in operation in daily life can be attained by most people, and is at a rather elementary level. However, to recognize the partial derivative as it explains and appears in dynamics of solids is of a far higher abstraction and certainly of a far higher level of appreciation. The intensity of appreciation at various levels may be the same.

Appreciation can only come as a result of growth in *mathematical responsiveness*. We must constantly teach for this. This involves a number of areas of learning, the most important of which are:

(a) A growth in mathematical *apprehension*. By this is meant the recognition of mathematics in all phenomena surrounding us. The parabolas in lenses, the hyperbolas in shadows from lampshades, the loci of moving objects, the arithmetic in the newspaper, the proportional formulas for variables representing physical phenomena, etc. We must *see* mathematics wherever it occurs.

(b) A growth in mathematical *application*. By this is meant a sort of inner compulsion to want to use mathematics to solve our problems. We want to work out our interest rates in borrowing or buying in instalments; we want to express our quantitative problems in terms of variables, functions, and equations; we deliberately seek the geometric relations in planning or designing any structure. We *want to use* mathematics.

(c) A growth in mathematical *abstraction*. This is a feeling for the use of the proper and best mathematical explanation. We use algebra where arithmetic would be complex and inelegant. We use trigonometry to explain periodic functions; we use the binomial theorem to explore higher dimensionality. We *select* the elegant mathematical exposition.

(d) A growth in mathematical *ability*. More and more, as we become steeped in our subject, we develop ability to use all of its algorithms, its propositions, and its methods in attacking new problems. When confronted with a puzzle or a problem, the acquisition of these skills, techniques and relations permit us to put all our attention to the *discovery* of new relations, and hence to the search of new mathematical forms. We must become *clever* in mathematics.

Finally,

(e) A growth in mathematical *insight*. The examination of a prob-

lem is accompanied by a sudden revelation of a mathematical pattern. We see a sea-shell and all of a sudden the spiral and its mathematical properties of growth, jump out at us. We hear a discussion and the logical structure of a deductive proof displays at once the truth or falsity of the argument; we see a building and the principles of symmetry and perspective tell us it is or is not satisfactory in design.

All of these phases mean not only a continuous accumulation of mathematical knowledge, but also a change in intellectual behavior, a more mature approach to the interpretation of our universe (environment). Merely juggling numbers, x's and y's, logical terms, and drawing figures, has no value for appreciation or for growth. It is meaning, discovery, creation, generalization, and total abstraction achieved by an inner drive and through one's own resources, that will lead to appreciation.

More could be said, but this must be acquired by reading further books and articles listed in the bibliography.[1] The foregoing, however, is sufficient to give us an understanding of the nature of appreciation. The following quotation from H. Poincaré can lead us further toward a formal psychological definition of appreciation; then illustrations from elementary mathematics can give deeper and more concrete significance. Poincaré said, "It may be surprising to see emotional stability invoked in mathematical demonstration, which, it would seem, can interest only the intellect. This would be to forget the feeling of mathematical beauty, of the harmony of number and forms, of geometric elegance. This is a true aesthetic feeling that all real mathematicians know, and surely it belongs to emotional sensibility."[2] It is this feeling that we can give to our fellow students, if we allow them the spirit of discovery, and this is appreciation.

Appreciation is, in essence, an aesthetic sense of *form*. Form is a value that is perceived, felt, and thought. When thus recognized, whether it be in music, in art, in logic, in geometry, in botany, the form gives appreciation. It is the recognition of the mathematical form, its ever occurring and repetitiveness in our environment that gives appreciation. The individual develops "a feeling for the form he wants" and the recognition of the form gives appreciation. Thus,

"Appreciation is the emotional pleasure (satisfaction) accompanying the successful quest for form."

This definition may be further clarified by the following additional attributes. It is the appraisal and recognition of a value, of "form." The form may be spatial, numerical, symbolic, or logical.

It is the gratification and aesthetic satisfaction arising from the ap-

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[1] Appended at end of article.

[2] "Psychology of Invention in the Mathematical Field." Jacques Hadamard, Princeton University Press, 1949, p. 31.

plication of mental discrimination in the mathematical field.

It is a more sensitive awareness of higher abstractions in spatial and numerical analysis.

It is an emotional sensitivity to cherished concepts of quantification and logic.

It is a quantitative procedure for using in directing one's own philosophical inquiries.

All of these attributes combine for a comprehensive understanding of appreciation of mathematics. It involves an intellectual stimulus for activities beyond the work-a-day life that lead us to cherish, esteem, and prize the old and new mathematical concepts and skills that we perceive.

Perhaps one of the most pervasive and awe-inspiring concepts of elementary mathematics is the Golden Section. How little use we make of it! The gradual development of this ratio in our algebra and geometry classes can illustrate all the foregoing aspects of appreciation. Space will permit only the outline of the development of this ratio, but every alert teacher can fill in each step.

1. Consider $\sqrt{5}$, its irrationality, geometric construction, and approximate value.

2. Consider $(\sqrt{5}-1)/2$ and $2/(\sqrt{5}-1)$ as reciprocals with values $0.618\cdots$ and $1.618\cdots$ where in each case the $\cdots$ signifies the same infinite sequence of digits. For these numbers $N\cdot N'=1$ and $N'-N=1$.

3. What positive numbers differ from their reciprocals by unity? This leads to $x^2+x=1$ and $x=(\sqrt{5}-1)/2$. Call this number G.

4. Consider the geometric sequence $1, x, x^2 \cdots x^n$, in which it is given that any term is the sum of the next two terms. Thus $x^n=x^{n+1}+x^{n+2}$ or $1=x+x^2$ and $x=(\sqrt{5}-1)/2$.

5. Divide a line into extreme and mean ratio. Then $1/x=x/(1-x)$ or $x^2+x=1$.

6. In an isosceles triangle with vertex angle 36° and side of length 1, bisect the base angle. The ratio of side to base is given by $x/(1-x)=1/x$ or $x^2+x=1$.

7. If a regular decagon is inscribed in a unit circle, the side has the length $(\sqrt{5}-1)/2$.

8. The regular pentagon is replete with the ratio G. See article by H. Baravalle in the January 1948 issue of *The Mathematics Teacher*.

9. The five fifth roots of unity are given by $x-1=0$ and $x^4+x^3+x^2+x+1=0$. Both sides of the latter equation are divided by x^2, and $x+1/x$, replaced by y, giving $y^2+y=1$.

10. Tying a knot in paper produces a regular pentagon with edges and diagonals divided into ratio G.

11. A continued fraction

$$x=\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{}}}$$

gives $x=1/(1+x)$ or $x^2+x-1=0$ or $x=G$.

12. A continued radical

$$x=\frac{1}{\sqrt{1+\sqrt{1+\sqrt{1+}}}}$$

gives $x^2+x-1=0$ or $x=G$.

13. This ratio is called the Divine Proportion, Golden Proportion, and Celestial Proportion.

14. Fibonacci develops a sequence on the growth of pairs of rabbits 1,1,2,3,5,8, . .

15. The ratio of terms of the sequence 1/1, 1/2, 2/3, 3/5 . . . has the limit G.

16. Start with any two numbers for example, 4, 7, and add successively to get 11, 18, 29, ... Here the ratio of $t_n/(t_n+1)$ has the limit G.

17. A rectangle $l=1+G$, $w=1$, can be successively enlarged by adding squares, or diminished to similar rectangles by cutting off squares. This gives the whirling square and the logarithmic spiral $\rho=a^{\theta}$.

18. The Fibonacci sequence is used to explain marine animal growth and arrangement of leaves, petals, cone spores, etc. (Phyllotaxis).

19. The number G is present in such aesthetic aspects as (a) dimensions of most pleasing rectangle, (b) dynamic symmetry, (c) geometrical design and art, (d) the invention of form, (e) perspective in painting, (f) the construction of vases and pyramids.

If you have understood all or some of these ever recurring phases of x in $x^2+x-1=0$, or $(\sqrt{5}-1)/2=.618$, then you either have or have not a feeling or desire for this mathematics. If you do, you will see it as it recurs again and again throughout your life, and you will enjoy it. You will have appreciation of the extreme and mean ratio. You can now well understand why Pacioli called this ratio the "Divine Proportion," why Leonardo da Vinci referred to it as the "Golden Section," and how Kepler, with all his religious awe, could call it the "Celestial Proportion." When it comes, and we see it, we too should have the emotional sensibility that gives real satisfaction.

Finally, let the hero and his love be one mile apart, the hero at A, his love at B. As A starts for B he travels at a rate of one mile per minute or $s=t$ (s in miles, t in minutes). His love (as it often appears

to be the case in real love situations) travels from B in the same direction according to the law $s=1/t$, that is, at the start $(t=0)$ his love is at an infinite distance, but in one minute his love is only 1 mile further from B. When will A overtake his love? For A the distance is $1+x$ and since $s=t$, $1+x=t$. For B, $s=1/t$ and since the distance is x we have $x=1/t$. Eliminating t we find $1+x=1/x$ or $x^2+x-1=0$ and the hero and his love meet at the Golden Section, a place where all true lovers should meet.

This growth in apprehension, application, abstraction, ability and insight is not only in G, but in every phase of mathematics. It is in the number zero, the binomial theorem, abstract algebra, and symbolic logic. If we will teach with a creative discovery, invention, problem-solving point of view, we can develop within our students a genuine satisfaction with, and a deep appreciation for, mathematics.

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OUR HERITAGE, THE LAND*

Louis Bromfield
Malabar Farm, Lucas, Ohio

Few people realize or understand that very close to 50 percent of our population is dependent upon agriculture as the source of its income and employment. Actually only about 20 percent of the population is engaged directly in a more or less productive agriculture but agriculture and the productivity of our soil lies at the base of the great agricultural machinery business, the greater part of the mail order house business, large segments of the gas, oil, rubber and steel industries, the vast milling and packing house trades. It provides a great portion of the revenue of our railroads and is the economic base of virtually all our small towns and cities as large as Omaha, Kansas City, Des Moines, Montgomery, Alabama, Minneapolis and countless others. It supports largely whole segments of the "servicing" in the form of the filling stations, garages, department stores, etc., which have become so important an element of our highly industrialized national economy. Therefore agriculture and a good, productive agriculture becomes of vital importance not only from the point of view of employment but also from the point of view of the agricultural purchasing power which largely supports industry and in turn provides employment and consequently the additional purchasing power of the great segment of industrial workers. In other words when farmers cannot go to town to buy tires or radios or automibiles it means not only that hundreds of thousands of industrial workers are thrown out of work in Pittsburgh, Detroit, Chicago and elsewhere but that *their* purchasing power is, in turn, curtailed sharply or cut off altogether.

Likewise, if we have a poor agriculture which produces commodities either in too small quantities of through inefficiency at high prices without profit, the consumer's market becomes limited by the increasingly high prices created by scarcities or the high cost of inefficient production, and consumption is limited with a depressing effect upon the employment based upon agricultural production and consequently upon the purchasing power of the non-agricultural element dependent upon agriculture for employment.

It might be said with considerable truth that every depression we have experienced since the Civil War has begun at the agricultural and with the shrinking or disappearance of the purchasing power of

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the agricultural segment of our population and spread through the whole of our national economy.

One of the great errors of many economists particularly in Washington has been to think of agricultural production in terms of *total* production rather than in terms of production *per acre*. During the war we achieved a record of *total* food production but never in any country at any time has food been produced so expensively—so expensively indeed that even with high prices it has been necessary to create subsidies (paid in the end by the consumer out of his pocket in the form of taxes) in order to get sufficient production. This is so because the cost of production per acre or per bushel was so high.

That cost has been increasing steadily since the first furrow was turned on this American continent, for the simple reason that the production per acre in so many areas has been steadily declining. In the corn belt areas which once produced as virgin soil without fertilizer yields of 120 bushels per acre, averages have declined within the past few years to as low as 37 and 44 bushels per acre. In the cotton area, where one acre once produced two bales of cotton, some cotton farmers are today farming six or seven acres to produce one bale. Beyond that point, even with parity prices and subsidies, cotton can only be produced at a loss and the land is abandoned to weeds and scrub oaks and pine. There are millions of acres of such land, producing no real wealth, employment or purchasing power and in many cases paying no taxes either to county, state or nation. The annual production of wheat in this country is only twenty bushes per acre as opposed to sixty bushels in France. And so it goes all along the line.

Let us examine what this declining production really means, first to the farmer himself, his prosperity, his purchasing power and the value of his land and second, to the nation itself.

It is perfectly clear, I think—as simple as the addition of two and two—that the corn produced by a farmer who gets yields of only twenty bushels per acre must cost him five times as much to produce per bushel in terms of labor, seed, taxes, interest, wear and tear, and possibly fertilizer as the farmer who produces 100 bushels on one acre. The farmer who produces two bales of cotton on one acre can produce it approximately ten times as cheaply as the farmer who produces one bale on five acres. In other words, the good farmer—the 100 bushel, two bale per acre farmer—is always five to ten times as well off, regardless of prices than the poor farmer producing low yields per acre. If prices are high, the good farmer is rich; if they are low, he is always solvent.

These estimates and the mathematical formula regarding declining production per acre and increasing cost of production hold equally

true in relation to forage crops, to pasture production, all the way through the cost of a quart of milk, a dozen eggs, or a pound of meat, etc., as well as in relation to the farmer's profits on all of these items. The speaker knows the question from the manure spreader and the plow upward as a dirt farmer interested in practical economics. In an adventure devoted to the rehabilitation of 1100 acres of farm and grazing land we have been able to increase production from 50% to 1500% per acre from a very low level. In our Ohio country on grazing land which once required from 10 acres upward to carry a cow or a steer through the summer in poor condition, we have raised some pasture land through the use of minerals and pasture mowing to a carrying capacity of one head *per acre* with steers pastured on it increasing weights in growth and meat from 250 pounds upward during the grazing season. The results and increased profits in terms of taxes and interest per acre alone need scarcely be explained.

Low Costs

Let me add here another important factor . . . that the process of restoring this land was not an expensive one. Occasionally I hear that we can do many things at Malabar Farm because we have a lot of money to spend. This is an excuse usually made by farmers and others who themselves are not doing a good job. We have never had unlimited money to spend at Malabar but more important is the fact that there has been from the beginning of the enterprise a strict rule that nothing was ever to be done in the buildings or in the fields which *any* farmer and I mean *any* farmer could not afford to do. Those of you who have seen the operation know that this is true by the evidence of your own eyes. The job of restoration at Malabar was accomplished by hard work, observation, experiment, imagination and the immense knowledge which is available and free to any farmer who wants to obtain the information and put it into practice. Including everything from the Extension Service to the State Agricultural Colleges, about 3 billions of dollars is spent annually in the aid and education of farmers. It is a sad fact that the results are so unimportant.

But to return to the question of declining production per acre in so many areas, let us take the case of American industry. American industry produces more telephones, more automobiles, more locomotives, more of almost anything you wish to name than all the rest of the world put together. As a rule these commodities are of better quality than the same commodities produced elsewhere. Usually they are sold at a much lower cost than the same commodities produced by other nations. And at the same time American industry pays its workers from ten to ninety percent higher wages and makes the living standard of American industrial workers by far the highest

in the world. How does it do this? It does it by high and efficient production per man hour, per unit, per dollar of investment.

Exactly the same rule applies to our agriculture and the possibilities of high production with lowered costs to the consumer and increased profits to the farmer.

This question of declining production per acre or per bushel and increasing cost of production per acre or per bushel—which operates according to mathematical law—lay at the root of the ruin of many farmers who sought to expand their production in the period of high prices during and after the First World War. Their error lay in expanding horizontally rather than vertically.

Let us examine what this means. According to informed authorities of the Department of Agriculture, only about 10% of our farmers produce anything near to 100% of potential production per acre through a good and efficient agriculture. These are the 10% who largely feed our immense urban populations. Another 30% produce from 50 to 60% of potentiality. The remainder produce little or no more than they consume. They are the marginal and submarginal farmers who produce little or no real wealth, pay few taxes and in many cases are liabilities rather than assets to the whole of the nation's economy. Each year, their number dwindles as they are forced on to the road to become migratory workers, paying no visible taxes and living part of the time on relief, or into the great cities as industrial workers to be cared for in times of depression or even of average employment. In some states, where the average cash farm income is as low as \$160–\$170 a year, some of these families see as little as \$5.00 a year in actual spending money. Their value, to the nation's economy, becomes, in view of vast government expenditures to bolster agriculture, that of liabilities. In the lowest categories their cash incomes and its insignificant effect as purchasing power or to bolster industrial employment by buying industrial commodities becomes negligible or is entirely wiped out by the fact that we spend on agricultural agencies in this country approximately \$13.00 per person—not per farmer but per person of the agricultural population. In few other ways can the cost of low agricultural production per acre be better illustrated.

But to return to the question of horizontal as opposed to vertical expansion and its evil effect upon the economy of the farmer—let us take one of those farmers who are what might be called average "good" farmers—the thirty percent who produce from fifty to sixty percent of what they might produce per acre if they were really good and efficient farmers. Let us suppose that John Smith, of this category, owns 200 acres and wants to increase his production because corn or wheat or cotten are bringing high prices. Instead of staying

home and producing the 40 to 50% more he could produce on his own 200 acres at very little increase in the cash cost of production per acre, he goes out and buys 200 more acres of land. As a result he has not increased his production per acre. He probably farms his whole 400 acres less well so that he produces less per acre both on his original 200 acres and on the 200 he has purchased, while his cost of production remains the same or has probably increased. This is especially true in war or boom times when labor and machinery are scarce and the costs of whatever he purchases or hires to cope with his increased acreage, including the price of the new land he has purchased have risen to abnormal heights. He has possibly borrowed money or mortgaged, to purchase the additional two hundred acres or used capital which could be much more profitably used as a reserve or to increase the productivity per acre of his original 200 acres.

When war and boom prices begin to fall, John Smith is caught. He has expanded his production horizontally rather than vertically and finds his comparatively low production per acre unequal to the job of paying additional interest and taxes and mortgage payments. Banks and insurance companies need the money and eventually are forced by a deflating economy and legal circumstances to foreclose, acquiring thousands of acres which they do not want, cannot sell and which costs them money to operate. And the foreclosure takes place not at the level of high prices which John Smith paid for the additional 200 acres but at the deflated prices of a period of depression on all 400 acres and John Smith is wiped out.

That is the story of millions of acres of farm land during the deflationary period which followed the war boom of the early twenties. If John Smith had stayed at home and increased his production by the 40 to 50% he could have done, the margin would have been almost pure profit, with no additional taxes, interest or mortgage payments. He would have been solvent and even prosperous with his 100% potential production per acre off-setting much or all of the decline in prices. By increasing his acreage and expanding horizontally he ruined not only himself but lost altogether the purchasing power so vital to the general employment and industrial economy of the nation. Eventually industrial workers are thrown out of employment because John Smith and his fellow farmers cannot buy the commodities manufactured by industry and in turn *their* purchasing power is not only cut off but they go on relief paid for out of taxpayer's money and capital which should be used to provide new enterprises, new employment and new markets. That is the story of some millions of acres of agricultural land during the deflation that followed the First World War, and largely speaking it is the story of the effects of decreasing agricultural production per acre everywhere and at all times.

The tradition of horizontal expansion like that of poor farming has grown largely out of the history of a nation with the largest pool of virgin natural resources and real wealth for its size in the world. We farmed poorly and greedily for the past 150 years because we could afford to do so. We had what appeared to be unlimited areas of rich virgin agricultural land. If a farmer mined one farm, he had only to take another further west and mine that one and then another, for free or at most for a dollar an acre. In that process we have destroyed one fourth of our good agricultural land beyond use save as possible forest land. Another fourth is on the way out and the rest, save for small areas of land owned by intelligent and wise individual farmers, is subject to the same depletion of organic material and minerals, to the same soil erosion that has created such havoc with our agriculture and national economy.

Following previous wars, even up to 1918, there was always free agricultural land to be taken up by Veterans as a reward for their services. Today there is none and we are paying, all of us, including the Veterans themselves, out of our own pockets, taxes to make up the recompense. It can be said that no country in the history of the world has ever destroyed its real wealth in the form of agricultural land and forests as rapidly as this one. This destruction manifests itself not only in actually destroyed land, in increasing numbers of marginal and submarginal farmers and dispossessed farm families who take to the road or migrate into our already overcrowded cities —it manifests itself also in steadily increasing costs of food, the basic item in the cost of living, in consequently declining standards of living, in constantly increasing demands for raises in industrial wages and the prices of manufactured commodities.

The destruction and declining production of our agricultural land lies at the root of a creeping inflation that has been in progress since the Civil War and which in the long run will be more devastating to the health, living standards, incomes and prosperity of the nation than any temporary war time or artificial boom inflation. We are approaching a subsidized agriculture. Indeed many agricultural commodities are already subsidized. If we pay increasing prices for agricultural commodities across the counter we are either starting the inevitable vicious spiral of increasing wages, increasing prices of industrial and agricultural commodities which constantly lowers the purchasing power of the dollar and the standards of living of our people. As agricultural production per acre declines and costs increase and as our population increases we are moving exactly along the path which brought ruin to Chinese government, economy and civilization.

Farmland Inflation

We hear much talk today of the inflated price of agricultural land. I doubt that there is much inflation involved in the slowly but steadily increasing prices of good agricultural land. The answer to the rising prices is that we are increasing our population at the rate of close to two millions a year, and we are reaching a point at which surpluses, at least in food commodities, are beginning rapidly to disappear or not to eixst at all. Indeed, as is the case with beef and some other high protein foods, we are experiencing scarcities today—scarcities which are not likely to be met by increased supplies for another generation or two. Indeed supply in the case of meat in particular may *never again* catch up with demand.

In the case of the high prices of beef, the situation exists simply because of three elements (1) More and more people want what beef there is. (2) More and more people have the money to buy it and in particular the choice cuts. (3) There is not enough beef.

Under such conditions the price can only rise until at last the commodity is priced out of reach of the average income. No amount of price control agencies can cope with these fundamental economic facts. They can be met and the condition solved only by putting more and more beef on the market at lowered prices but at stable or increased profits to the farmer. The only answer to this is high production per acre on the one hand of range bred calves and on the other of the grain that goes to the animals in the feed lot to finish them off. The supply of beef will not be increased if the farmer does not make a profit. It will only be diminished and one source of correction and higher profits at least lies with the farmer and cattle man themselves. Prices will not go down or profits up or the supply increased by methods which farm five acres of corn to produce what one acre of corn should produce or by grazing methods which have reduced the carrying capacity of cattle in many areas from a steer to five acres to a steer to twenty-five or fifty acres.

Some of the figures concerning livestock production unearthed by Congressman Hope, former chairman of the House Agricultural Committee recently are startling. In 1900 the population of this country was approximately seventy-five millions. In 1951 the population had more than doubled but actually there are less beef cattle, less dairy cattle and less sheep in this country today than there were fifty years ago. Under such conditions and with high wages, only one thing can happen . . . that the price of these foods goes up steeply and cannot come down. Inflation has much less to do with rising farm prices than the laws of supply, demand and the ability to purchase.

If we pay higher prices in subsidies rather than in cash across the

counter, we are taking money out of the pockets of our citizens, through increasing taxation (either visible or invisible) and then constantly decreasing their purchasing power and draining away the capital which should be employed in a free nation and under a free enterprise system to bolster its economy by providing employment and developing its real wealth. One of the foolish illusions held by many people along with the illusion that money is real wealth, is that scarcity and high prices mean prosperity and high living standards. Exactly the opposite is true. A large part of government regimentation has grown out of an effort to deceive ourselves into believing that we are maintaining our living standards by government bribery of the people, by subsidies and by high tariffs which are essentially no more than subsidies. We tax ourselves more and more in order to hold down living costs, devouring our economic vitals to do so and bringing ourselves constantly nearer to totalitarianism government, regimentation and a lower and lower standard of living. We are trying to deceive ourselves into the belief that we still possess vast reserves of real wealth in the form of natural resources and that these reserves are still highly productive. Neither assumption is true. The truth is that in the face of a rapidly increasing population we have destroyed our natural resources more rapidly than any other nation in the history of the world and we are rapidly approaching the economic pinch and the lowered living standards which have existed in Europe for three centuries and in China and India for an even longer period.

Our wealth, our economy, our power as a nation are not founded upon the gold buried at Fort Knox but upon our real and natural wealth. It, therefore, becomes imperative that we make the best possible use of the real wealth in the form of minerals, ores, oils, etc., and that we barter our manufactured commodities, either directly or through the use of money and exchange in a three or four cornered form of barter, for these raw materials and real wealth which we have utterly dissipated or never possessed. This is true even if we did no more than stockpile these lacking raw materials against future use to bolster our economy and the real sources of our high living standards.

In all the vast pool of natural resources and real wealth which this country once possessed, agricultural land and forests are the most important and vital. This is so primarily because they are the sources of real wealth which are, if properly managed, constantly renewable and constantly productive of more real wealth. This is also true because as the supply of minerals, oils, etc., becomes more and more depleted, we turn more and more to agriculture and forests for the substitutes which can replace them. Our productive forest areas have been reduced to less than a sixth of their original size and during the

war we cut down our forests approximately five times as fast as we have been replacing them. Fire in unmanaged areas takes each year a terrible toll. We have destroyed a fourth of our good agricultural lands and are constantly wearing out through erosion or poor farming what remains to us of this most precious of all our real wealth and natural resources.

All of this was what Bernard Baruch, greatest of the world's practical economists, was talking about when he made to Congress what was to this nation perhaps the most important statement of our generation and century—a statement which was largely overlooked and seems already forgotten. It was this—that we had best make an invoice of the real wealth and natural resources which are left to us before we go on distributing them around the world with a lavish hand in the form of manufactured commodities either for free or for money. Mr. Baruch knew what all of us should know—first, the real basis of our wealth and power is our natural resources and second, that money paid in exchange for these resources either processed or as raw materials only creates inflation and shortages and lowers living standards, unless this money is in turn spent outside the nation for raw materials and real wealth which is the very heart's blood of nations in the industrial age in which we live.

What we need in this country is not more dollars but dollars which buy more and more, and we shall only get dollars which buy more through intelligent use of our natural resources and real wealth. We shall only get dollars which buy more and more and raise rather than lower the living standards of our people through abundance with greater production, lower costs and profits for all. Each day our dollars buy less and less and each day there are new strikes, new demands for higher prices for industrial commodities and higher ceilings and parities for the farmer. In all of this both production and abundance suffer and as scarcities increase and prices go up, living standards and prosperity decline.

I am certain that the lips of some of you are already forming the word "surpluses." Surpluses, like so many other shibboleths of our day, are an illusion. For at least two generations in this nation there has never been any such thing as a surplus save in a few single crop areas where men have stubbornly gone on producing year after year the same commodity, despite falling demands in the world as a whole. Cotton is the pre-eminent example. When coupled with a declining demand, the costs of production increase and the yields per acre decline, a surplus is inevitable, especially in the face of world competition.

But in the realm of food, there is no such thing as surpluses in a world where three quarters of the population suffers from malnutri-

tion and a quarter of it is born and dies without ever having had enough to eat for one day of its life. There is no such thing as surpluses in a nation like this where, despite potentially great agricultural resources, 40% the population suffers from malnutrition either because of ignorance or because it cannot afford to buy high quality protein food. There is no such thing as surpluses; there is only poor distribution and prices which are too high, and the prices are high because of a poor agriculture and declining yields per acre along the whole range of food and feeds.

Never in the history of the world has the folly of the "surplus" theory with regard to food been so tragically exposed as at the present time. While half of the world starves we are experiencing actually shortages in this country. The truth is that if our government representatives and officials spent half as much time on better production and better distribution of food commodities both here and abroad as they spend in patching up price regulation, price controls, tariffs, parities, etc., we should have a market both in this country and in the world which would consume at good prices to the farmer much more food that we can possibly produce at the present time. There could and should be some system by which the food of the world can be distributed properly either by direct barter or through the use of exchange, with economic advantage to all concerned. It is one of the things which should concern our State Department, our Department of Agriculture and most of all, perhaps, the United Nations Organization. To talk of agricultural food surpluses in this country or in the world is absolute nonsense. It is an excuse made by politicians who seek to buy their votes with the use of taxpayers money and who have not the brains or initiative or energy to find the true and fundamental solution—better distribution and greater not less production per acre.

Those who talk of surpluses overlook nearly always the factor of high prices and their constricting influence upon markets. In other words, with beef steak at 25 cents a pound as against 85 cents or a dollar a pound, the consumption would increase at least twenty times and it would be under existing conditions impossible for the farmer or cattleman to satisfy the demand. The same is true to a greater or less degree of all foods.

Certainly, under existing agricultural conditions costs of food can scarcely be reduced overnight without disaster to the farmer, but that is so because it costs far too much per acre to produce a bushel of corn or a pound of meat. The change cannot be made overnight. We have made a good start in certain areas of the country but a really efficient, profitable and prosperous agriculture without subsidies and such panaceas can only be achieved over a period of years.

Since the Civil War the economic history of the nation has been largely that of violent booms and violent depressions, violent inflations with short periods of doldrums in between. There has never really been a period of genuine and stabilized prosperity in which the farmer, the business man, the manufacturer could plan with any certainty for more than a couple of years ahead. Such a stabilized prosperity is what we need and only abundance, low prices and a stabilized purchasing power for the dollar will give it to us. All that, of course, is based upon the proper care and employment of our real wealth and natural resources. The money will take care of itself.

In our basic triumvirate of agriculture, labor and industry, the best place to make a beginning is with agriculture. In an agriculture such as is practised in Denmark, Holland, Belgium and France with a hundred percent production per acre, there is no such thing as a poor farmer, even in bad and disturbed times. The agricultural wealth and solidity of these nations lies largely behind the fact of their stability and rapid recovery as compared to a nation like the United Kingdom, which lacks both the real wealth and the purchasing power of a sound and productive agriculture. If we had in this country as efficient land use as in these nations the cost of food and of other agricultural commodities could be reduced as much as 30% or more and the farmer would be making 20% more profit than he is making today. It is largely a matter of production per acre.

Subsidies, tariffs, parities, price ceilings, bribes to agriculture—all of these are makeshifts which deal with effects rather than causes. They solve nothing but only continue to undermine our prosperity and living standards. Because of the gravity of agricultural conditions at the present time, some of these measures must be continued in one form or another. Some of them must be continued so that the farmer can be helped to help himself. But in the long run they are no more effective than a plaster placed on the outside of the stomach to cure a stomach ulcer. The real answer is the stopping of floods and soil erosion, either by wind or by water, better and more productive grazing lands—and a better and more productive agriculture—in short, abundance with low production costs and the guaranteed security which comes of high production per acre. What we need as a nation is dollars that buy more and more for everybody—farmer, industrial worker, business man. We shall only get that through abundance in all our production—agricultural and industrial. What we need is corn at 50 cents a bushel with a good profit margin rather than subsidized corn at a dollar a bushel produced at a loss to the farmer. There is one way to get all this and that is through the preservation and restoration of our greatest source of real wealth—the soil—through better land use.

Optimistic Note

Recently through the P.M.A., the Secretary of Agriculture has tried to make cheap and demagogic political capital out of the so-called "family-sized farm." Few expressions are more confusing or indeed more meaningless than "the family-sized farm." Presumably it means a farm which will make a decent living for a family of five or more people. A family-sized farm in some areas might be ten acres from which, under specialty production, a family could produce a net income of many thousands of dollars a year while in other areas a family might starve to death on fifty thousand acres.

Size in itself has comparatively little to do with income from a farm. What counts is not the number of acres so much as the brains, the work, the knowledge and above all the program of any farm, regardless of size. The phony theory of "the family-sized farm" has actually cost the nation many hundreds of millions of dollars, especially in the semi-arid areas of the West and Southwest which are essentially grazing and not agricultural land. Many millions of acres of this new land was broken up into holdings as low as 160 acres per family. On such small holdings no one could make a living out of the range cattle to which the country was suited. They went into row crops of cotton and corn to pay taxes, interest and have a little spending money. With winter floods and summer droughts crop failure or near crop failures were inevitable two years out of three and the heavy rains under row crop conditions brought about an erosion which destroyed the land sometimes in a generation or less. The crop of "Okies" in the thirties was produced less by the immediate conditions of the Great Depression than by the long range policy of dividing land into holdings that were too small and eventually brought about the destruction of the individual farmer's land which was his capital. Much of what I have said appears to be pessimistic but I would not choose to leave such a total impression.

The fact is that our agricultural practices and the value of our agricultural land are on the whole improving steadily and will continue to do so, through grim economic necessity if for no other reason. The battle in behalf of soil conservation has been won. More than eighty per cent of American farms are now included in soil conservation districts locally organized and locally administered at the grass roots. The day when terraces, strip cropping, contour plowing were considered new-fangled is over and today in most communities the farmer who does not practice such methods is regarded as backward by the rest of the community. The Four H. Clubs, the F.F.A. boys and girls are turning out good farmers with a wholly new point of view. They do not believe that their land owes them a living and they regard farming as a business like any other business in which a man

invests a dollar to make three or four dollars. They do not believe that "what was good enough for grandpappy is good enough for me" and they do not fall into that cheap error which has cost us as a nation billions of dollars . . . the error in thinking that *anybody* can farm. Agriculture . . . a good agriculture . . . is one of the most complex and difficult of professions and demands more knowledge about more things than any other profession since the beginning of time. This is a fact long recognized in such countries as Denmark, Holland, Belgium and France where there are neither bad farmers nor poor farmers. In such countries when you say farmer, you mean "a rich man." In those countries land is considered so valuable and so desirable that there is virtually no land for sale at any price save through sale to settle an estate.

But there is another ruthless force which is improving our agriculture and our land values and that is the sheer force and working of economic law. Each year in this country between 150 to 200 thousand bad, greedy and ignorant farmers are being liquidated simply by the force of economics, regardless of subsidies, pariety guarantees, floor prices or what you will. They simply arrive at last at a point at which the land will no longer pay taxes and interest and they sell out, or walk off and leave the farms they have ruined.

In many cases if not most cases this is a blessing for the farmer himself as well as for the nation and its economy. He can no longer go on destroying his own or the nation's natural resources and real wealth. In most cases he was a farmer only by the accident of circumstance. Often enough he hated his land and his livestock and sometimes his family because of the harsh conditions of his life and the pitifully low living standards which in many cases produced as little as five dollars a year spending money or less. If he goes to town he is likely to find better housing and better schools. He will work eight hours a day for five days a week. His evenings will be free and he will have more money than he ever had before in all his existence . . . money which will not only bring him enjoyment but also benefit the economy of the whole nation by its power to purchase the commodities both of agriculture and industry. Actually in most cases he should never have been a farmer in the first place.

Meanwhile the land he has left is going in most cases to better farmers who will build it up and add to the wealth of the nation. Any farmer today is a capitalist. As many of you know good farmers in the Middle West, even with farms as small as 120 acres, represent in land, machinery and livestock a capital of fifty or sixty thousand dollars.

In the long run all of this represents a single economic and sociological fact . . . that with a rapidly increasing population and a defi-

nite limit to the amount of land available, land itself is becoming too valuable to remain in the hands of the bad farmer and agriculture is acquiring the recognition good agriculture has always had—as both a business and profession, perhaps the most important the world has ever known.

SCHOOL FIRE SAFETY*

N. E. Viles

School fires endanger the lives of pupils, cause property losses, and may disrupt the school program for weeks or months. Schools have an obligation to develop and maintain fire-safe conditions in their plants. Responsibility rests on local and State school and other officials, teachers, parents, and custodians.

This bulletin stresses the importance of safe conditions in school plants, lists various hazards, and outlines certain procedures for avoiding or eliminating some of these hazards. It is designed as a guide for those interested in and responsible for school safety. It will also be of value to teachers as source material for class instruction in fire safety.

* Office of Education Bulletin 1951, No. 13. 58 pages. For sale by the Superintendent of Documents, U S. Government Printing Office, Washington 25, D. C. 20 cents.

THE NORTHERN CROSS

One of these clear nights the stars in the constellation known as the Northern Cross will give up the answer to a minor but puzzling irregularity in the time-table of the heavens, according to Prof. C. M. Huffer, University of Wisconsin astronomer.

The puzzle involves the star known to scientists as 31 Cygni, located about halfway between Deneb, the brightest and topmost star in the Northern Cross, and Delta, the star which marks the tip of the right arm of the Cross.

31 Cygni is a twin star—actually two stars which revolve around one another but which are so close together they appear as a single point of light. One is red and cool, the other is white and hot. The white and hot star is currently eclipsed by the cool, red star—an event which occurs once in every 10 years.

The eclipse began early in August—sooner than astronomers expected—and predictions said it would last considerably less than a month and a half. At the latest observation, however, the stars were upsetting the sidereal time-tables prepared by the world's astronomers by remaining in total eclipse.

"The eclipse was predicted for December," Professor Huffer points out, "and it was expected to last for as short a time as a week or two."

When the mystery will resolve, Professor Huffer is not willing to say. Amateur astronomers will not know when it does as quickly as the professionals—because the star, though easily visible to the unaided eye, will vary so slightly in total light and color that the difference will only be detectable by use of photo-electric instruments.

SHELTERBELTS, WITH SPECIAL REFERENCE TO THE GOVERNMENT SHELTER-BELT PROJECT

ARTHUR P. HUTT
Port Clinton, Ohio

For more than a century, the term shelterbelt[1] has been known and used by the farmers of the United States who realized the need to protect their land, crops, livestock, and homes from frigid winter winds and scorching summers. As the need for protection became more apparent with the settlement of the western plains, the pioneers had little to guide them in their efforts at planting shelterbelts. With the exception of plantings on the Russian Steppes by German settlers, little was known about such plantings.

It was not until 1932, however, that any extensive and controlled plantings were made in this country. Today, shelterbelts are profitably used throughout the nation, but it was the Government Shelterbelt Project from which most of our scientific data and conclusions were drawn.

As one Kansas City editor put it, "God alone can make a tree, but only Roosevelt can make a tree belt." In 1932, when President Roosevelt was forced by a train wreck to spend several hours in a windswept desolated area near Butte, Montana, the idea of a government shelterbelt project occurred to him, but was rejected by his advisors. Two years later when the severe drought and dust storms began, the plan was approved and submitted to the United States Forest Service for investigation and formulation of details. Despite severe political criticisms, lack of funds, and a reduction of the scope of the plan, the work that has been done has proved successful.

A shelterbelt may be defined as the planting of trees and shrubs in strips wide enough to protect land on the leeward side against dry prevailing winds which erode and desiccate the soil. The original plan called for a strip one thousand miles long from Canada to Texas, which would include the states of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. The width of the shelterbelt was to be one hundred miles, broken up into strips seven rods wide and spaced a mile apart, and running north and south. The total area in the belt was figured at 100,000 square miles (64,000,000 acres), and the planting area was 1,600,000 acres or about 14 acres per section. Of the 400,000 square miles of plains country about one fourth was involved. Although most of the land was privately owned,

[1] A shelterbelt may be defined as a strip of trees or bushes varying from one to several units in width, and designed to protect extensive areas such as fields. A windbreak is a clump of trees or bushes which protects a smaller area, such as a homestead.

it was thought that through cooperative agreements, direct purchases, or long time leases this would present no obstacle. Cost of the program for the ten years needed to complete it would reach about $75,000,000 with money coming from drought relief appropriations. Ten million dollars (later reduced to one million) was given to the Secretary of Agriculture to meet the cost of the first year.

No claim was made that the project would stop droughts, although many antagonists were quick to twist the words around. However, it was thought that the severity of the drought would be lessened by reduction of velocity of the hot summer winds, less evaporation from the soil and transpiration from the plants would occur, and snow would evaporate more slowly. It would provide permanent and dependable protection to an area where the elements have always made life hazardous and income uncertain. Another important aspect of the bill was that it would provide employment for farmers who were dependent upon agriculture but who were then out of work because of the drought. It was not thought that benefits would extend beyond the immediate belt, but that the benefits from this project might stimulate or influence others to be established.

At first the strips were to be continuous, but this was modified by the Forest Service because of soil conditions and local obstacles. A depth of seven rods per strip was selected to assure that the trees and shrubs could protect themselves against the drying winds. The planting stock was to come from government, state, and private nurseries. Native tree species that had shown they could grow in the region, and trees from other semi-arid areas were selected for the first plantings in 1935, and planted in the early spring so they could become established before the drought of the summer. The list of hardwoods included green ash (*Fraxinus pensylvanica lanceolata*), box elder (*Acer negundo*), cottonwood (*Populus sargentii*), Chinese elm (*Ulmus pumila*), osage orange (*Maclura pomifera*), Russian olive (*Eleagnus angustifolia*), chokeberry (*Prunus virginiana*), and mulberry (*Morus rubra*). Conifers selected were the jack pine (*Pinus banksiana*), western yellow pine (*Pinus ponderosa*), red cedar (*Juniperus virginiana*), scotch pine (*Pinus sylvestris*), and Colorado blue spruce (*Picea pungens*). Rate of growth and resistance to drought were the factors involved in selecting the trees. Poplars, the fastest growing, would grow to 25 feet in twenty years. To plant the whole area as originally planned three and one half billion (2500 per acre) trees and shrubs would be required if spaced three feet apart in rows, and the rows ten feet apart.

Many people questioned the direction in which the belt was to extend as each was most concerned about his local problem where the winds were often north and south. Generally though, westerly winds

prevailed, but it was admitted that in some areas the north and south belts would have to be supplemented by east and west belts if good results were to be obtained. Many questioned the belt's location on the east side of the prairie as the prevailing winds were westerlies. However, any more westerly location would not have enough rainfall.

In 1873 a Timber Culture Act in the West had failed because the early settlers had no knowledge or experience with what trees to plant or how to plant them. Also, a lot of this early planting had been done only to obtain a title to the land and thus was not done carefully. Skeptics of the project were quick to make comparisons, however.

Allowances were made for the fencing of the belt for protection against wildlife and livestock. Thinnings from national parks in Montana, Wyoming and Colorado were treated with preservative and used for the fence posts. The entire project called for 30 to 50 million fence posts, 8 to 9 feet long, 5 to 6 inches in diameter and set in the ground $2\frac{1}{2}$ to 3 feet deep. Galvanized wire and three strands of barb wire were recommended. Where jack-rabbits were abundant individual wire screening was necessary.

In Russia this type of work had been carried on for 245 years, but systematically only the last 90 years.[2] The climate of the steppes is similar to that of our plains. Summers are hot with dry prevailing winds; the spring season is very short; rainfall is only 10–12 inches falling mostly as cloudbursts during the summer months; relative humidity varies from 10 to 65 per cent. The soils, as in the United States area, are chernozems and chestnut-browns. The best trees for these conditions were found to be oak, maple, and ash at the initial plantings, with elm or Caragana planted three years later. The climate of the steppes was not modified by these plantings, but the areas within the shelterbelts were greatly improved for agricultural purposes. It was found that the most important things to consider were the soil conditions, the proper selection of trees, and the careful management of nurseries. Trees grew despite severe droughts, and where they failed it was due to the cheapness of the plantings, not the silvicultural practices.

Initial plantings of the United States shelterbelt were begun in the spring of 1935 after a year of investigation of factors by the Forest Service. This agency studied the rainfall and climatic factors, soil and subsoil conditions as related to tree growth, the adaptability of different trees to the soil climate and drought conditions of the area, and the form of the shelterbelt which would give the most protection.

When the project started misunderstandings and violent opposition developed.[3] Even among the forestry leaders in the United

[2] Mirov, N. T. "Two Centuries of Afforestation and Shelterbelt Plantings on the Russian Steppes," *Jour. Forestry*, 33(12), pp. 971–973, 1935.

[3] Butler, Ovid (Ed.). "Pros and Cons of the Shelterbelt," *Am. Forests*, 40(11), pp. 528–529, 1934.

States, opinion was divided. Henry Graves, Dean of Yale Forestry School and former Chief Forester with the United States Forest Service, favored much modification of the plan. He asked for a cooperative set-up with much federal support, which eventually resulted. C. B. Waldron, Head of the Department of Forestry and Horticulture, North Dakota Agriculture College opposed the plan because he felt that the trees, as they matured, would not get enough water for their increasing demands. Other plans, such as the Timber Culture Act of 1873 had failed for this very reason. He felt that it should be a local project done independently by the farmers, and duplicated every twenty-five years—at which time, he said, the trees would be dead. Other responsible men felt that the belt should not be continuous, but that only certain areas fit for planting should be selected, and that the land selected should lie fallow for at least a year so that it could gain moisture. As the work progressed some of the opposition was dispelled.

In 1936 the shelterbelt project as originally adopted was abandoned because of public and political criticism and insufficient funds. Congress appropriated $170,000 to maintain the trees which had been planted. Plantings to date (1936) covered 24,300 acres and cost $3,000,000, much of which went for research. Eighty per cent of the plantings were in good condition. Despite the drought of the spring of 1936, two year old Chinese elms had reached 15 feet, and cottonwoods 16 feet from 18 inch seedlings planted in the drought spring of 1935. Pocket gophers and rabbits had proved to be more destructive in some areas than the lack of moisture.

A new plan was adopted in 1937 called the Prairie (Plain) States Forestry Project. This project abandoned the continuous-belt idea and gave aid to farmers within the area who were willing to prepare and to set aside strips of land around their farms for shelterbelt planting. The government supplied the trees and the necessary fences, and most of the planting was done by W.P.A. labor. The farmers were expected to cultivate between rows for about four years, or until the shade from the trees was able to keep the weeds from smothering out the seedlings. Thus, the cost of the project was about fifty-fifty. In 1938, 65,000 man-months of relief labor were spent on this project. A total of 83,000,000 trees had been planted at this time with a survival rate maintained at 80 per cent. The cost of planting an acre of trees was about $30, and the cost was declining. Since it only took $8\frac{1}{2}$ acres of trees to protect 160 acres the cost for most farmers was not prohibitive.

Even though most of the trees were too small for any far reaching influences to be noted, many farmers saw that there was less soil movement through wind erosion, and that where seeds previously had

been blown out of the ground necessitating reseeding this condition was rarely experienced now. Insectivorous birds began to make their appearance. For many people the attractive changes in the landscape were enough to make the project worthwhile.

By 1942, 190,000,000 trees had been planted, and they provided protection to 27,000 farms totaling 4,000,000 acres. In the same year the administration of the Prairie States Forestry Project was transferred to the Soil Conservation Department from the Forest Service on the theory that the project was one of conserving soil rather than one of forestry. Since Congress had repeatedly refused to appropriate money for the Forest Service but had consistently appropriated money to the Soil Conservation Service, the move was beneficial, but short-lived. In 1943 the Soil Conservation Service was asked to drop the work, despite its popularity and approval of those who had been directly affected.

A survey group in 1944 toured through the six states involved and examined 1,079 belts and recorded notes on surface and subsurface soil, water table, damage by disease, insects and other causes, the height, crown spread, survival, vigor, ground cover, continuity of row, and seed production of each species.[4]

Two types of belts were predominant. One type started on the windward side with low shrubs, and gradually increased to the tallest trees. It contained fewer rows of trees, and had the slow growing permanent shrubs and trees backed by the more rapid growers. The original type of strip tapered in both ways, and usually contained about twice as many trees. Both types proved to be highly satisfactory. Rows within belts were about ten feet apart to allow for tractor cultivation in the early stages, and to favor crown closure which simulated true forest conditions, and discouraged the growth of weeds and scrub species. In some areas a leaf mulch from one half to one inch had formed. Belts of less than six rows of trees did not approach forest conditions because the wind blew the litter out of the belts, and the sun could reach inside the belt to burn out the humus. The optimum number of rows was from seven to ten. Where farmers had spaced their rows 24 to 30 feet apart for ease of tractor cultivation, only limited protection was offered to the crops and to the soil. Within rows the best spacings were six feet for trees, and three feet for shrubs. The average age of all strips was six and one half years, with the tree heights averaging around twenty feet.

Among the deciduous tree species planted the plains cottonwood (*Populus sargentii*) was the most spectacular.[5] In some belts in Texas

[4] Munns, E. N., and Joseph H. Stoeckeler. "How Are the Great Plains Shelterbelts?," *Jour. Forestry*, 44(3), pp. 237–257, 1943.

[5] Stefferud, Alfred (Ed.). "A Selected List of Shrubs and Trees for Planting Windbreaks and Shelterbelts in the Great Plains," *U. S. Dept. Agric. Yearbook for 1949*, pp. 848–849. 1949.

seven year old trees had reached fifty feet. This species does best on friable sandy soils with a high infiltration rate and of moderate water-holding capacity. Where it was planted in loams and clays in light rainfall areas it grew extremely slow or died within three to four years. Variations in soil texture often produced ragged silhouettes where perhaps within twenty feet one cottonwood would be tall and well-formed, and another would be short and poorly-formed. When planted with Siberian elms, the competition for surface water was too great, and since the elm has an immense shallow rooting system, the cottonwoods usually died out. Also, cottonwood is subject to Texas root rot (*Phymatotrichum omnivorum*), Cytospora canker, wetwood wilt disease, and attacks from insects—mainly borers of the genus *Dendroctonus*. The white willow (*Salix alba*) was superior to the cottonwood both in survival percentage and freedom from disease and was used to substitute for it on soils where the cottonwood would not thrive. Planting of the species was done only on a small scale, however. Box elder (*Acer negundo*), also used sparingly, showed great promise as it formed a closed canopy quickly, produced a decent leaf mulch, and had a high survival rate. Ailanthus (*Ailanthus altissima*) had an excellent survival rate, but was objectionable due to its tendency to sucker profusely. Black walnut (*Juglans nigra*) and the Kentucky coffee tree (*Gymnocladus dioica*) did well on most of the soils in the belt but their open crowns and heavy branches detracted from their value. The Siberian elm (*Ulmus pumila*) is one of the best shelterbelt trees. It creates a dense shade, and even with the leaves off the dense network of twigs is efficient as a windbreak. It is subject to freezing and wind breakage, but quickly resprouts from adventitious shoots or root sprouts. Often it grows so rapidly that it overtakes the more cold-resistant native trees. Other hardwoods that did well were the green ash, the black locust (*Robinia Pseudo-Acacia*), the honey locust (*Gleditsia triacanthos*), and the catalpa (*Catalpa speciosa*).

Conifers require a longer period of cultivation to keep them free of weeds as their lateral spread is not nearly as fast as that of deciduous trees. Their slow growth rate also subjects them to crowding by the faster growing species. Of the eleven species of conifers planted, the eastern red cedar and the Rocky Mountain juniper (*Juniperus scropulorum*) were the most outstanding. They are relatively free from insects and disease, are adapted to a wide range of soil and climatic conditions, and survival rate is usually near one hundred per cent, if properly cultivated. Jack pine and Scotch pine were at their best only on well-drained soils free of alkali and carbonates which limited their useage. Ponderosa pine, once established, proved highly desirable as it is long-lived and has an extensive crown system. Its

survival rate was very low, probably due to nursery practices of cutting the tap root too short and of destroying some of the fibrous root system. When transplanted in the field, the young trees could not stand the shock. Spruces did not survive too well, and took too much pampering to produce results. Drought, heat, and weeds caused most of the spruce losses.

Shrubs are especially valuable to close in the outside edges of the belt, thus affording a barrier close to the ground. Buckthorn (*Rhamnus dahurica*), American plum (*Prunus americana*), common chokeberry, lilac (*Syringa vulgaris*), and Russian olive generally had the best survival rate and value throughout the entire belt. Other good shrubs which were not adapted to the whole area but which did well in limited areas were the caragana (*Caragana arborescens*) on dry sites and the osage orange and redbud (*Cercia canadensis*) from Nebraska southward.

The sloping surface of the individual strips has an influence on the wind directly proportional to the height of the strip. As the wind approaches it is forced upward and if the rows are properly spaced, as it descends again toward the ground it will be forced upward by the next strip. On the leeward side the area is protected a distance equalling twenty times the height of the strip. Even on the windward side, a back pressure is built up and this influence extends for a distance ten times the height of the strip.

The soils within the belt are predominantly chernozems and chestnut-browns.[6] Both have a zone of accumulation of calcium carbonate at a depth dependent upon the rainfall. Below this area they are dust dry, and the water table is not uncommonly 100 to 200 feet below the surface. The soils on the east side of the belt are rich in organic matter; those on the south and west are not. Silt loam and fine sandy loam are the main soil types although heavy clay loams and sands are also present. The soils in general are considered favorable for plant growth if they receive enough moisture. Sands are considered to be the best if moisture requirements are sufficient. In sandy soils there is hardly any loss through runoff as most of the water is absorbed, and the sandy texture creates better mulch conditions against evaporation loss. General soil conditions had not been changed by the strip except in some areas a forest mulch condition had developed.

Trees weakened by drought are often attacked by insects. Grasshoppers were the most important defoliating insects that occurred in the strips and where infestations were severe they completely defoliated the trees, and then started to eat the bark. The flatheaded apple tree borer (*Chrysobothris femorata*) was also closely associated

[6] Morgan, M. F. "Soil Factors in Relation to Proposed Plains Shelterbelt Plantings," *Jour. Forestry*, 33(2), pp. 137–138, 1935.

with drought and weakened trees. The adults chewed the leaves at the petioles and brought about defoliation. In 1934 thousands of elms were killed in this manner. Spring canker worms (*Paleacrita vernata*), and the hornworms (*Protoparce* sp.) were also very destructive. Since the advent of DDT, control has been relatively simple. Jack rabbits and other rodents often completely girdled the younger trees in winter, and protection against them was difficult. Fire caused some losses. Many farmers had allowed their livestock to graze among the strips, and the results were destructive. Their browsing among the lower branches of the trees reduced the effectiveness of the planting by opening up the lower portion of the strip to winds, their hooves injured the roots, and eventually the soil became puddled.

All factors considered, the shelterbelt project was a success. Today with the basic knowledge and incentive supplied by this government project, farmers across the nation are successfully and profitably applying the same principles.

Soils are being protected from erosion which removes the fertile top-soil. Run-off is being checked. Crops are shielded from hot, scorching, dry winds. In one plains state, this type of protection accounted for a $60 gain in grain production on many farms. Reseeding caused by the grains being blown out of the ground is rarely necessary. By decreasing wind velocity, loss of water from the soil by evaporation is retarded. Livestock survive the winter in a much healthier condition, gain more weight, need less food, and are more prolific. Farmers now have a continuous supply of wood for their own needs. Social conditions have been improved. A greater variety of crops can now be raised. The strips are providing a haven for all types of wildlife, especially for insectivorous birds. Some plains farmers have reported savings of over $15 per winter in their fuel bills. Recreational areas have been developed, and landscapes improved. Cheaper than storm fences, plantings are sometimes used to protect highways from drifting snow. Many California citrus groves are protected by towering eucalyptus trees which increases yield noticeably. One important factor in this connection is that the bees can work undisturbed by winds and there is more complete pollination in a protected grove. All in all, shelterbelts and windbreaks are proving their value to the economy of our nation and to the nation's backbone—the land.

Radioactivity detector is a direct-reading quartz fiber instrument to measure radiation intensity which can be used in low range survey work or in the higher ranges following the release of large quantities of radioactive materials. When used in higher ranges, the instrument is inverted to throw a loosely-hinged resistor into position.

THE TEACHING OF COLLEGIATE MATHEMATICS

CECIL B. READ
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As many who have taught on the college level are well aware, there is relatively little material available that is helpful to the beginning college teacher. There are magazines which offer excellent articles on teaching elementary and secondary school mathematics, and the research man can find much material published in his special field. The teacher starting out with classes on the first two years of college mathematics finds, aside from the very few articles, no sources which offer help.

With the idea of making some contribution to this field, SCHOOL SCIENCE AND MATHEMATICS plans to publish, over a period of several months, material which would be of value. It has been decided that the articles should not be formal in nature but rather should be informal presentation. Probably several brief items will be more likely to be read than a long discussion, to say nothing of the value of different points of view.

After some consideration it was decided to ask certain teachers who have been rated by their colleagues as outstanding teachers of undergraduate mathematics to write an informal letter, such as they would send to a close friend, perhaps a young graduate who is just beginning to teach in a college—probably on the first or second year level of mathematics. Although the form of a letter was suggested, it was not given as compulsory. Aside from limitations of space there is no restriction. Moreover, there will be no editing of the material—it is recognized that because of different concepts of teaching, there may be contradictory statements.

For the first article SCHOOL SCIENCE AND MATHEMATICS is happy to present a letter from Professor R. G. Sanger, Head of the Department of Mathematics of Kansas State College, Manhattan, Kansas. It is of interest to note that in 1940 Professor Sanger was awarded a $1,000 price (from an anonymous donor) at the University of Chicago for excellence in undergraduate teaching, President Hutchins personally making the award.

Dear ————

Your recent letter implies that you are now teaching collegiate mathematics, and that you are wondering what makes a "good teacher." The last is a very hard question to answer. However, I will try to make a few appropriate comments on effective teaching.

First, and last, remember that you are a human being, and that your students are human. As their teacher, you should be considerate, helpful, fair, kindly, but not be a doormat that can be blithely trodden upon. There are limits to helpfulness, as there are to everything, and some students will overstep all bounds in making requests for help. Such requests have to be turned down tactfully, and with a reason for the refusal. There exists an invisible line between teacher and student which is sometimes hard to locate, but which is there just the same, and respect is lost by both parties if that line is passed.

When presenting material to a class, try to present it at a level of the average student in the group. There are always a few genii in a class who will consider your presentation elementary, and also several who will not follow you under any condition. One is sorry for the latter group, but one should not slow up a class for the very weak ones. If they are worthy of mathematical salvation, extra time should be given them outside of the classroom.

In the past you have had many teachers, and have approved of some, and disliked others. Each teacher had his particular method of teaching. Try those that appealed to you. Some of them may work for you, others may not, but all are worthy of consideration.

When you enter the teaching profession, there is always the question of, will you be able to do research? The decision rests solely with you, but remember, it is important to keep alive mathematically, be alive to the interests of the community in which you live, participate in local activities, and have positive interests outside the scholastic world. All of these things take time, and there may not be time for all of them and creative research.

In the actual classroom, you will probably develop your own special, individually stylized method. However, there are a few minor points which can be noted and which will be appreciated by the student. On the first day of class, be sure to announce your name, office hours, office location, name of text, days class meets, and your system of grading. The last is particularly important from the student viewpoint. When making assignments, write them on the board, and if possible, make them well in advance. Students may then plan their time accordingly, and also will not be able to say "I did not understand the assignment." If you collect homework, grade it carefully, and return it promptly. Papers that have been kept by an instructor for weeks have lost all value to the student. If you do not use a strict lecture method, be sure to have all of the class participate to some extent. Short questions are better than utilizing the Socratic method on one individual. Personally, when asking questions, I first call on those who are trying to sleep, then those who are talking to their neighbor, then those who are reading a book, then those who are

yawning, and lastly, those who are paying attention. Another way of getting class participation is by the use of board work. For elementary classes, where a certain amount of drill is needed, and where there are students who will do no problem unless it is specifically assigned, such work helps. By watching the student attempt extemporaneously assigned problems, the teacher can spot errors and points of weakness, and can clarify these points at a later date. Many other items could be pointed out, but as it is now nearing lunch time, I will close.

Hoping that this letter may give you some suggestions as to how one might become a successful teacher, I remain,

Sincerely yours,
R. G. Sanger

OBSERVATIONS ON BURNED-OUT LAMP FILAMENTS

Julius Sumner Miller
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When an incandescent lamp bulb "burns out" it is generally assumed that the lamp is irreparable. This is so if the filament has a large gap in it, as when a piece of some length, say 2 or 3 millimeters, drops out. If, however, the filament is only broken so that the filament circuit is open by the merest gap, it is often possible, indeed, invariably possible, to join the free ends by welding. This is easily accomplished by shaking the lamp, with the power on, and if this mechanical action brings the filament ends close enough an arc may develop which will weld the junction. This detail is fairly well known and most of us have experienced it.

The question may now be asked: how will the bulb now perform? This I find to be a good elementary question in the beginning course for a number of factors are involved, such as filament length, filament area (cross-section), Ohm's law, wattage, luminous flux, luminous efficiency, and so on.

Another detail which I particularly wish to report and which I find not so well known is this: when the restored lamp again "burns out" the filament circuit does not give way at the weld but invariably at a new place. This appears to be in keeping with standard metallurgical theory concerning the properties of a deep-welded junction.

NEWS CHATS

The Central Scientific Company of Chicago has issued an interesting and instructive publication called "Cenco News Chats 72" containing articles about progress in research laboratories, the American Concrete Institute, a biographical sketch of "the father of modern reinforced concrete," Arthur Newall Talbot, and instrument developments for laboratories. The Cenco-Lyle phase demonstrator, a classroom projection meter for reading amperes and volts, a new student molecular model set and an alpha ray apparatus are among the instruments described. Request "Cenco News Chats 72," Central Scientific Company, 1700 Irving Park Road, Chicago 13, Illinois.

A COMPARISON OF TWO METHODS OF TEACHING FORMULA WRITING IN HIGH SCHOOL CHEMISTRY*

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AND

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INTRODUCTION

The teaching of formula writing in high school chemistry has in the past been largely a process of memorization without much understanding. An examination of textbooks in the field of high school chemistry revealed that much stress is placed on memorization of valences and the mechanical use of these valences in writing formulas. Most of the textbooks provide tables of valences for the most common elements and radicals. Teachers of high school chemistry in many instances have asked students to memorize these valences and then have asked students to write formulas according to a set of rules. Anderson has stated: "One of the weaknesses in the teaching of high school chemistry is that, at the end of a year's work, students are unable to write correctly the formulas of many chemical compounds, unless they have learned them by rote. Memorization of formulas does not lead to a comprehensive understanding of valence, and neither does the student appreciate the structure of compounds. Equation writing and problem solving, based on equations, are made so much easier if the student has the basic tools of formula writing firmly fixed in his chemical habits."[1]

Thus, we see that the writers of textbooks of chemistry have placed a value on the process of memorizing. However, Bayles[2] stressed a thorough knowledge of valence and a thinking out of formulas. In addition, most writers of high school textbooks have stressed that the ability to write formulas is a requisite to writing equations and the solving of chemical problems based on formulas or equations. Thus, the problem of how best to accomplish these ends with a maximum of understanding is paramount.

The above discussion does not relegate the process of memorization from chemistry instruction. Memorization is a useful process when

* The title of the Master's Thesis submitted by Mr. Colyer in partial fulfillment of the requirements for the degree of Master of Science in Education. Kenneth E. Anderson, adviser for the thesis.

[1] Kenneth E. Anderson, "A Method for Teaching Formula Writing and Structural Diagraming in High School Chemistry," SCHOOL SCIENCE AND MATHEMATICS, 47: 46–47; January, 1947.

[2] Ernest E. Bayles and Arthur L. Mills, *Basic Chemistry for High Schools*. New York: The Macmillan Company, 1947, p. 227.

properly used. However, the point of view taken in the above discussion was simply that rote learning often resulted in little or no real learning, and that when the material to be learned was made more meaningful, greater transfer took place. It was the contention of this study that the usual methods of teaching formula writing employed by high school teachers of chemistry could be made more meaningful and thus result in greater transfer on the part of the high school student. The student should be able to do more than recall the formula of a compound when given the stimulus in the form of compound name. In possessing a more complete understanding of valence and formula writing, he should not only be able to write formulas for familiar chemical compounds but unfamiliar chemical compounds as well. He should find this ability useful in the further extension of formula writing to equation writing and in the solution of problems based on formulas and equations. Such a method has been suggested by Anderson[3] who stated: "There are many methods of teaching formula writing. The writer has found over a period of years, that if students are taught formula writing and structural diagraming by the method illustrated in this paper, they gain an excellent foundation for the work to come later in chemistry. The method has value in that it gives direction to the teaching of formula writing."

The Problem

The purpose of this study was to test out, in several chemistry classes in Kansas high schools, the method suggested by Anderson. For sake of brevity, Anderson's method hereafter will be referred to as the *Sequence Method*. The problem therefore became one of testing the hypothesis: formula writing as taught by the Sequence Method produces greater achievement in formula writing than does the Traditional Method. The hypothesis may be stated as a null hypothesis. The task then became one of accepting or rejecting the null hypothesis.

The Traditional Method

An examination of several chemistry textbooks revealed that the approach to formula writing was essentially the same in each in that there was prior to formula writing, an explanation of atomic structure, atom activity, symbols, valence, prefixes, and suffixes. The similarity continued when actual formula writing was explained. Thus, it was believed that there was enough similarity in method in the several textbooks to constitute a method called the Traditional Method.

According to the Traditional Method, the student would proceed, as follows, in writing a formula of a chemical compound:

[3] Kenneth E. Anderson, *op. cit.*, pp. 46–47, 188–190, 269–271; January, February, and March, 1947.

1. The symbol of the element or radical having a positive valence is written first, followed by the symbol or radical having a negative valence. Radicals such as (NO_3) and (PO_4) act as elements and usually pass through a chemical reaction unchanged. Thus, in the formula for cupric nitrate, copper has a positive valence and the nitrate radical has a negative valence. The student would write the symbol for copper first and the symbol for the nitrate radical second as follows:

$$Cu\ (NO_3)$$

2. Since all inorganic compounds are electrically neutral, the number of positive charges must equal the number of negative charges. Thus, the valence of each element or radical is written at the upper right of the symbol as follows:

$$Cu^{++}(NO_3)^-$$

In order to make the compound electrically neutral, two (NO^3) radicals are needed. This can be accomplished by crossing the valences over as follows:

$$Cu^{++}(NO_3)^-$$

or

$$Cu(NO_3)_2$$

3. Whenever possible the subscripts are reduced or the least common multiple of both valences is found. Thus, with aluminum phosphate, the steps are:

$$Al^{+++}(PO_4)^{---}$$

$$Al_3(PO_4)_3$$

$$Al_1(PO_4)_1$$

$$Al\ PO_4$$

This reduction rule is always used except that the student must be mindful of exceptions. Thus, H_2O_2 could be reduced to HO but H_2O_2 is the real formula, and hence should not be changed to HO.

In addition to following the above steps in writing formulas, the student is asked to memorize the valences of several elements and radicals. Most books provide such a table of valences. In addition, most books provide some practice exercises in the form of a table, the positive elements or radicals along the vertical axis and the negative elements or radicals along the horizontal axis. A few of the more progressive books give a token treatment to structural diagraming but these are exceptions. Thus, the Traditional Method provides the mechanical wherewithall to write formulas but with a minimum of understanding. A well trained and conscientious teacher can provide

the understanding but if she does so, she has departed markedly from the Traditional Method as usually taught.

The Sequence Method

The Sequence Method[4] was so named because an examination of the method reveals that it is built upon a series of interlocking steps. We find that these steps consist essentially of (1) word understanding, (2) valence understanding, (3) writing the empirical formula, and (4) diagraming the empirical formula as a check.

Since the Sequence Method was outlined previously in School Science and Mathematics (see footnote 3) and since a more complete description of it is available,[4] the method will not be described in detail here.

Comparisons of the Methods

The Traditional Method seems to depend solely on memorized facts, that is, to write formulas purely by the rote method. It is believed that memorizing a few facts, as in the Traditional Method, is not sufficient. The student needs more explanation, more understanding, more of the know-how in formula writing. The traditional Method does not seem to go far enough into trying to explain how formulas are built in space. Proof of the empirical formula is needed to strengthen the knowledge of the student.

The Sequence Method tries to exceed and simplify the Traditional Method by word understanding, valence understanding, writing an empirical formula and proving it by diagraming the empirical formula. The Sequence Method makes use of the nomenclature in conjunction with writing the empirical formula, for out of the name of the formula comes information as to what the empirical formula shall be.

Thus, the Sequence Method is different from the Traditional Method in that it places greater stress on:

1. Understanding the nomenclature of chemistry.
2. Understanding valence.
3. Writing the formula of the acid prior to writing the formula of a salt.
4. Drawing the structural diagram of an empirical formula as a check.

Thus, in the Sequence Method, the student gains a more complete picture of the use of prefixes and suffixes in the naming of chemical compounds and the relationship of the prefixes and suffixes to the proper choice of valence. This is most important.

[4] Kenneth E. Anderson, "A Method for Teaching Formula Writing and Structural Diagraming in High School Chemistry," University High School, University of Minnesota, 1947. Mimeographed Bulletin, 8 pages. (a copy of this bulletin may be had by writing Dr. Anderson at the University of Kansas.)

In the Sequence Method the student works directly from the name of the compound and the table of valences provided. He does not memorize the valence of a radical but actually works out the valence of the radical from the basic acidic element. If he has forgotten the valence of a radical, he can by this method easily reconstruct the valence from the name of the compound.

In writing the formulas of salts, the student derives the formula of the acid first, and then knowing the valence of the acid radical, he proceeds to write the formula of the salt.

As a last and final step, the student proceeds to draw the structural diagram using the valence of the acidic element as a point of departure. The structural diagram serves as a check on the empirical formula and also provides the student with an understanding of the tie-up of all the elements in the compound.

Thus, the Sequence Method provides the wherewithall of the Traditional Method but with more definiteness and with more understanding. Students, once acquainted with the essentials of the method, can write the formulas of unfamiliar compounds. This is impossible under the Traditional Method of teaching formula writing. Thus, the Sequence Method should result in greater transfer than would be the case under the Traditional Method of formula writing.

The Sample

The sample for purposes of comparison consisted of four chemistry classes in which formula writing was taught by the Traditional Method and of four chemistry classes in which formula writing was taught by the Sequence Method.

These eight schools had to be located within driving distance of Oberlin, Kansas. None of the schools was more than two hours driving distance from Oberlin, Kansas. It was necessary for the writers to instruct the teachers in the four experimental schools in the methodology of the Sequence Method.

Since the formula test used as a pre-test was the same as used for the post-test, it was necessary to give the test as a pre-test and collect the copies immediately, so that no copies remained in possession of the teacher during the instructional unit. The same precaution was observed with the post-test as the unit on formula writing occurred at different times in the eight schools. All schools completed the unit on formula writing before the Christmas holidays.

Two studies by Anderson[5,6] have shown that the following factors had an effect on achievement in high school chemistry: (1) the size of

[5] Kenneth E. Anderson, "Summary of the Relative Achievements of the Objectives of Secondary-School Science in a Representative Sampling of Fifty-Six Minnesota Schools," *Science Education*, 33: 323–329; December, 1949.

[6] Kenneth E. Anderson, "A Study of Achievement in High School Chemistry in Several Eastern and Midwestern States," *Science Education*, 34: 168–176; April, 1950.

the school, (2) the number of different preparations of the teacher, (3) the chemistry credits earned by the teacher in college, (4) the type of college from which the teacher received her undergraduate degree, and (5) possession of a Master's degree by the teacher. The factor of the sex of the student and the factor of years of experience of the teacher, each had an effect on chemistry achievement in one study but not in the other study.

No attempt was made to secure classes taught by teachers of equal training in college chemistry, equal experience in teaching chemistry, and equal teaching loads. All of these factors and those mentioned by Anderson were not controlled in the present experiment, and therefore constitute a real weakness in the experimental plan. To have matched teachers on the basis mentioned above, would have required a more extensive sample of classes. It was felt that this was impossible under the circumstances.

However, the control classes and experimental classes were fairly well balanced with regard to the following factors: chemistry credits earned by teacher, years of experience of the teacher in teaching chemistry, the sex of the students, and the size of the school in which the classes were located.

Two of the control classes used the same text as did one of the experimental classes. Two of the experimental classes used the same text as did one of the control classes. The remaining one control class used a different text than did the remaining one experimental class. Thus, although the texts were different, there was some similarity or overlap in this respect.

An examination of the science courses taken by the students in the control and experimental classes prior to or at the time of enrollment in chemistry revealed that the students in the control group had a somewhat greater amount of previous training in science and mathematics than the students in the experimental group.

Thus, it would appear that the control classes and the experimental classes were fairly equivalent as regards the factors mentioned. If there were a slight advantage in favor of one group or the other, the advantage was in favor of the control group, all factors considered. In addition, the factors of pre-test knowledge and intelligence were controlled in the statistical calculations.

The Examinations

The Intelligence Test

The Otis Quick-Scoring Mental Tests, Gamma Test: Form Am[7] was given in each of the schools after the Christmas holidays. This

[7] *Otis Quick-Scoring Mental Ability Test, Gamma Test: Form Am*, World Book Company, Yonkers-on-Hudson, New York, 1937.

was done on a rotation basis and all of the intelligence testing was completed by March 1st. The scores on these tests were converted to I.Q.'s and used in the statistical calculations. In most statistical calculations, it is advisable to use the raw scores or mental ages, but since the range in chronological age was not great, no serious error was introduced into the calculations by using the I.Q.'s.

The Formula Test

The examination was prepared by the writers for this particular study. The test was made in two sections, each section containing forty-three test items. One hour was allowed for the pre-test and two hours of examination time for the post-test. Twenty-four of the eighty-six test items called for structural diagraming. This did not seem to be an undue emphasis on this phase of the work. The writers tried to use formulas found in most chemistry books. Thus, the test had curricular validity in that the test items called for writing formulas found in the texts used by the control and experimental groups.

The reliability of the formula test was determined by using a method, which approximates the split-half method, but sidesteps the Spearman-Brown Prophecy Formula. In addition, the method gives one a standard error of measurement. Two coefficients of reliability were computed, one for the control group and one for the experimental group The same was true for the statistic, standard error of measurement. The coefficient of reliability for the control group was .955 with a standard error of measurement of 3.06. The coefficient of reliability for the experimental group was .941 with a standard error of measurement of 4.54.

Statistical Analysis

Principles of experimental design, including statistics, must be brought into play in the advance planning stage of investigations.[8] Therefore, in this investigation, it was recognized that knowledge of formula writing prior to the instructional unit might vary from one chemistry class to another. In addition, the intelligence of the pupils might vary from one chemistry class to another. Since other investigations have shown the influence of these factors on final achievement,[9] it was decided to secure measures of pre-test knowledge and intelligence and hold these factors constant in the comparisons by using the technique of analysis of variance and covariance.

Whenever the analysis of variance and covariance technique is

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[8] Palmer O. Johnson, "Modern Statistical Science and Its Function in Educational and Psychological Research," *The Scientific Monthly*, 72: 385–396; June, 1951.

[9] Kenneth E. Anderson, "A Frontal Attack on the Basic Problem in Evaluation: The Achievement of Instruction in Specific Areas," *The Journal of Experimental Education*, 18: 163–174; March, 1950.

used, the data used in the comparisons should satisfy certain basic assumptions:

1. The measures or variables under consideration must be normally distributed in the population.

2. The classes to be pooled must be homogeneous with respect to variances and means of the dependent variable.

3. The pooled classes or pooled sub-samples must be homogeneous with respect to variances and "within groups" regression.

Only one of the distributions proved to be normal, that of intelligence. The post-test distribution departed somewhat from the normal distribution; the pre-test distribution was definitely non-normal. Thus in testing the second basic assumption, it was decided to test also for homogeneity of means of pre-test scores and intelligence, since the classes in the control group and in the experimental group varied widely as to means on the pre-test and varied some as to means on the intelligence test.

Thus, of the four control classes and of the four experimental classes, only two from each classification were pooled as they were considered homogeneous with respect to: (1) means on the pre-test, post-test, and intelligence test, and (2) variances on the post-test.

Thus, the groups for comparisons by means of analysis of variance and covariance were: Classes *A* and *B* of the control group versus classes *A* and *C* of the experimental group.

Other comparisons were possible such as:

(1) Control *A* and *B* versus experimental *B*.
(2) Control *A* and *B* versus experimental *D*.
(3) Experimental *A* and *C* versus control *C*.
(4) Experimental *A* and *C* versus control *D*.

These comparisons were not made as it appeared from the data that the groups to be compared would not be homogeneous with respect to variances and "within groups" regression. Since this was a definite possibility, the results would be inconclusive as pre-test knowledge and intelligence could not be controlled unless the technique of analysis of variance and covariance was employed.

Thus, the conclusion of this experiment will be based solely on the one comparison: control classes *A* and *B* versus experimental classes *A* and *C*.

The data for the control classes *A* and *B* were combined and the data for the experimental classes *A* and *C* were combined. Where the pooled classes homogeneous with respect to variances and "within groups" regression? Both of these assumptions were tested by Welch-Nayer L_1 test. Since the L_1 value in both instances was larger than the table value at the five per cent level, the two hypotheses were accepted.

Since all assumptions were met, it was possible to combine the data and calculate an F value on the adjusted sums of squares, using the within adjusted sums of squares, the between adjusted sums of squares, and the total adjusted sums of squares. Table 1 indicates that an F value of 6.31 was obtained which was significant at the five per cent level. Thus, it was possible to reject the null hypothesis at the five per cent level.

Which group achieved significantly more, the control or the experimental group? Table 2 indicates that the adjusted mean of the experimental group was 40.51 as contrasted to an adjusted mean of 29.35 for the control group. •

TABLE 1. ANALYSIS OF VARIANCE COVARIANCE OF FINAL SCORE WITH OTIS I.Q. AND PRE-TEST SCORE CONSTANT

Source of Variation	D.F.	S.S.	M.S.	F	Probability
Within	43	6950.13	161.63		
Between	1	1019.50	1019.50	6.307	
Total	44	7969.63			$.05 > P > .01$

TABLE 2. ADJUSTED MEANS

Group	Means Int.	Means Pre	Post	Diff. from Grand Mean Int.	Diff. from Grand Mean Pre	b_1	b_2	Corr. b_1	Corr. b_2	Adjusted Means
Control	110.042	4.417	32.042	−.36	−1.61	.4990	1.5601	−.18	−2.51	29.352
Exper.	109.304	1.130	37.609	.38	1.74			.19	2.71	40.509
Grand Mean	109.681	2.809								

CONCLUSIONS AND RECOMMENDATIONS

Thus, it was concluded that on the average and within the limitations of the experiment, the experimental group achieved significantly more than the control group on the formula writing test, holding constant the factors of pre-test knowledge and intelligence.

The results of this experiment have shown the value of the Sequence Method as outlined. Since the final test on formula writing contained formulas not previously written or memorized, there was evidence of transfer of training to new situations. It was contended that this took place because of greater understanding gained by using the Sequence Method.

Since formula writing is one of the basic skills of chemistry and since ability in formula writing must be obtained prior to equation writing and the solution of problems based on formulas or equations,

the method which aids students to gain ability in formula writing should be used. The results of this experiment have proven the value of the Sequence Method as contrasted to the Traditional Method.

Although the writers recommend the use of the Sequence Method for high school chemistry classes, they do so only if the user re-evaluates the results of this experiment in his own situation. The user must prove the worth of the method in his own chemistry classes.

THREE HORSE EVENERS

FRANK HAWTHORNE
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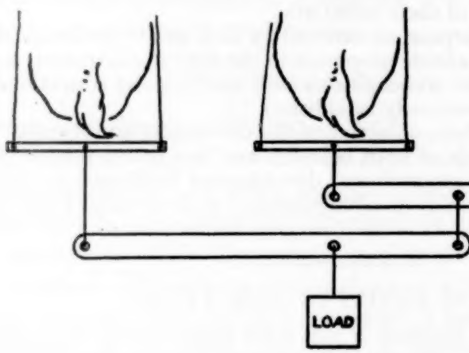
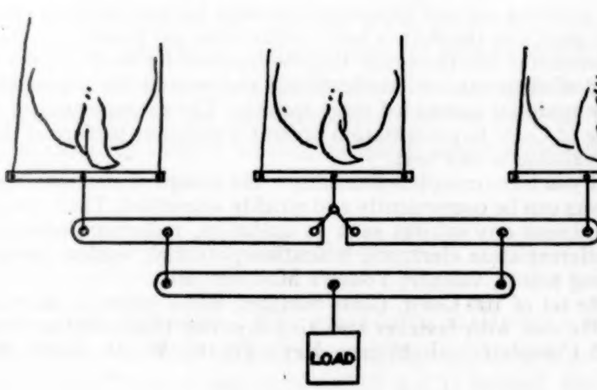
While in many rural sections the devices indicated in the diagram are familiar, many students, particularly in urban districts, will not recognize them. These contrivances were designed (I have no idea how long ago) to hitch three horses to a load and to require each horse to exert the same amount of force.





As examples of the application of the principle of the lever, I have found these to be very useful. In one case, the actual device was brought into the high school classroom and three volunteers tugged with zest. On other occasions, I fashioned small models from broken meter sticks and used spring balances to indicate the forces applied. The drawing illustrates the two types of three horse eveners with which I happen to be familiar. It is conceivable that the problem may also have been solved in other ways.

These devices are useful for demonstration purposes because they attract attention, are simple, are illustrative of basic laws, and appeal to the practical instinct.

GENERAL ELECTRIC AND CORNELL COOPERATE

A pioneering venture in educational and industrial research cooperation was revealed here today in a plan announced jointly by the General Electric Company and Cornell University for the establishment of an advanced electronics center at Ithaca, believed to be the first of its kind in the nation.

Initially, the center will occupy a large modernized laboratory building located on Cornell property adjacent to the Ithaca East Hill airport. Modification of the building, already begun, is scheduled to be complete by February, 1952. Employment at the center during its first year of operation is expected to reach 80 people, more than half of them scientists.

The project's over-all purpose, as outlined by G-E and Cornell officials, "is to carry out advanced study and development in the field of electronics, and at the same time provide scientists and engineers with teaching and educational opportunities of a type never previously established."

They cited as an immediate objective of the new center an attempt "to fulfill the rapidly increasing needs of both industry and the armed services for additional military electronics research and development facilities." It will supplement the company's electronics research activities at Electronics Park, Syracuse, and at Schenectady, N. Y.

COLOR SLIDES OF THE ATOMS

An excellent set of one hundred 2″×2″ color slides is ideal for lecture room study, discussion, or comparison of the structure and characteristics of the atoms. They are of particular value to the instructor who wishes to direct class discussion by specifically pointing out and explaining the data for each element, because in a projection of giant size the data is fully visible from any position in the lecture room. Full attention of the class may thus be focussed for study of any one element or family of elements, and students will understand the organization and function of the material assembled more quickly. The arrangement of symbols and the scheme of Color Representation present a complete picture of the atoms which is not available in any text.

With this set you have complete flexibility—the groups of elements best suited for your purposes can be conveniently and quickly assembled. They are available for discussing almost any subject such as oxidation, reduction, crystal lattice, electrolysis, differentiation electrons, ionization potential, nuclear composition, isotopes, melting points, valence, Young's Modulus, etc.

The complete set of 100 Color, Glass-mounted Slides comes in an attractive, black leatherette case with fastener and hinged cover. (Sold only as a complete set.) No. 3975 Complete with 48-page Key—$75.00. W. M. Welch Scientific Company.

OUTLINE OF THE HISTORY OF ALGEBRA

GEORGE E. REVES
The Citadel, Charleston, S. C.

INTRODUCTION

This outline is concerned mainly with the parts of algebra encountered in the solution of indeterminate equations and determinate equations. The solution of indeterminate equations usually requires the rational or integral solutions for the unknowns occurring in fewer equations than the number of unknowns. An example is furnished by the problem of finding integral solutions for x, y, z if $x^2+y^2=z^2$. The solution of determinate equations consists of two problems: (1) to obtain roots (if possible) by a finite number of rational operations and root extractions performed on the coefficients of the equation, i.e. solution by radicals. The quadratic formula is such a solution by radicals for the quadratic equation; (2) to obtain a numerical approximation to a root of an equation with numerical coefficients (Horner's method, Newton's method). The problem of (1) is of greatest interest in the development of algebra while the problem of (2) is of greatest importance in applications.

I. THE PERIOD BEFORE 1600

A. *The Ancient Period* (3100 B.C.–1 B.C.)

1. *Babylonian:* Some records in cuneiform script on tablets of about 2000 B.C.; solved special quadratics by rule without symbolism, solutions not checked or proved; solved certain cubics empirically; first instance of important method of transformation and reduction; simultaneous linear equations in two unknowns; proposed (did not solve) a general cubic concerning frustum of pyramid, proposed a quartic, one instance of a cubic in x^2; usually gave one root of an equation; knew equivalent of our quadratic formula with positive radical; three instances of negatives, astronomers of fourth century B.C. used correct rule of signs; one instance of ten equations in ten unknowns; solved an exponential equation by trial and error to find time for money to double itself; approximated square root by the rule

$$\sqrt{a^2+b^2}=a+\frac{b^2}{2a}$$

(this rule appeared 2,000 years later in Heron's work).

2. *Egyptian:* records in picture writing in Moscow papyrus (1850 B.C.) and Rhind papyrus (1650 B.C.); solved easy numerical

equations of first degree by trial.

3. *Chinese:* records in Ten Classics of period about 1112 B.C. to 256 B.C.; possibly solved (1100 B.C.) two linear equations in two unknowns by a rule like determinants; quadratics solve before time of Christ; first century A.D. solution of an indeterminate equation; third century A.D. writing indicates proficiency in algebraic manipulation; proportions and arithmetical progressions handled in the sixth century; numerical cubic equations occurred in the seventh century without details for solution.
4. *Hindus:* no pre-Christian records; considerable algebraic symbolism and techniques by time of earliest records about 400 A.D.; in the sixth century Aryabhata worked with arithmetic and geometric progressions, solved linear and quadratic equations, indeterminate equations in two unknowns, used letters for unknowns and seems to have known the binomial expansion for $n=3$.

B. *The Greek and Roman Period* (600 B.C.–600 A.D.)

1. *Pythagoras* (569 B.C–500 B.C.) (Pythagorean School until 350 B.C.): real roots of quadratic equations by geometry; solutions of the indeterminate equation $x^2-2y^2=\pm 1$ to give the successive approximations of $\sqrt{2}$ as

$$\frac{3}{2},\quad \frac{7}{5},\quad \frac{17}{12},\quad \frac{41}{29},\ \ldots$$

2. *Euclid* (365 B.C.–275 B.C.): Proved geometrically

$$a^2+b^2=c^2,\qquad a(b+c)=ab+bc,\qquad (a+b)^2=a^2+2ab+b^2,$$
$$(a-b)^2=a^2-2ab+b^2,\qquad (a+b)(a-b)=a^2-b^2;$$

geometrically solved simultaneous quadratics in two unknowns and found the positive root of $x^2+ax=a^2$, for a positive; proved complete integer solution of indeterminate equation $x^2+y^2=z^2$ (Lagrange next to give such proofs).

3. *Archimedes* (287 B.C.–212 B.C.): solved geometrically the cubic $x^3+ab^2=bx^2$; gave cattle problem to find integral solutions of $x^2-4729494y^2=1$.
4. *Apollonius* (260 B.C.−200 B.C.): used equivalent of coordinates in systematic treatment of conics.
5. *Heron* (75 A.D.): (perhaps Egyptian) solved quadratics similarly to method of Babylonians; used a symbol for "nothing."
6. *Diophantus* (75 A.D.): wrote 13 books of which 6 survive; indeterminate equations with emphasis on special solutions; beginnings of genuine algebra; special linear equations in two and

three unknowns; gave only one root for quadratics; used symbols operationally; invented a species of minus sign, permitted some formal use of negatives; used symbols for unknowns and for powers of numbers.

C. *The Hindu, Arabic, Persian Period* (600–1200). The Hindus obtained excellent results in indeterminate analysis and they made progress in a symbolic algebra. The superior Hindu notation was also used by the Western Arabs but the Eastern Arabs retrogressed to the earlier rhetorical algebra of the Greeks. The Arabs gave solutions of numerical cubics by geometric constructions which remained unknown in Europe until reinvented by Descartes and Thomas Baker.

1. *Brahmagupta* (early 7th century, Hindu): rules for negatives, found one root of quadratics, discarded negative root; complete integer solution of $ax \pm by = c$ (a, b, c integers); discussed Pell indeterminate equation

$$Cx^2+1=y^2, \quad (C \text{ not a square});$$

abbreviated unknowns, squares, square roots; dot for negative; fraction written with numerator above denominator without the bar.

2. *Mahavira* (9th century, Hindu): rule of signs for negatives; discarded imaginaries as inexistent (said negative had no square root). (A manuscript around 700 to 1100 gave the symbol + to indicate subtraction.)
3. *Al-Khowarizmi* (825, Arabian): wrote a text which influenced the development of algebra tremendously; introduced the word which developed into our word algebra for transposing negatives to give equations of positives only; ***returned to rhetorical algebra***, void of symbolism; shared in mathematical awakening of Christian Europe and introduction of Hindu-Arabic numerals; exhibited a negative root of a quadratic without explicitly rejecting it; solved geometrically equations like: $x^2+ax=b$, $x^2-ax=b$, $x^2+b=ax$.
4. *Al-Karkhi* (1010, Arabian): used rhetorical algebra; gave

$$a=w+\frac{a-w^2}{2w+1}, \qquad \sqrt{a+b\pm\sqrt{4ab}}=\sqrt{a}\pm\sqrt{b}.$$

5. *Omar Khayyam* (1045–1123, Persian): geometrical solutions of numerical cubics; did not accept negatives; classified cubic equations; thought cubics algebraically unsolvable and quartics geometrically unsolvable; additional algebraic development hindered by inadequate number concepts (may have

known Pascal triangle and binomial expansion for integral power).

6. *Bhaskara* (born 1114, Hindu): recognized two roots of quadratics but rejected the negatives, used $(2ax+b)^2=-4ac+b^2$; Brahmagupta notation for powers and fractions; stated division by zero gives infinity; discussed

$$ax^2+b=y^2 \quad (a,\ b \text{ non-square integers});$$

method of finding new sets of solutions of Pell equation from a set found by trial, did not determine whether he had all solutions (high tide of Hindu algebra).

D. *The Period 1200 to 1600.*

1. *Leonardo of Pisa* (1175–1250, Italian): expounded (1202) Eastern algebra; rejected negative roots but interpreted negative number as a loss; discussed special diophantine systems of second degree such as $x^2+5=y^2$, $x^2-5=z^2$, seemed not to realize should find all solutions; important instance of generality of algebra with use of a single letter to denote a number; unable to solve $x^3+2x^2+10x=20$ algebraically (gave an approximation of the root to 10 places of decimals), attempted to prove the impossibility of a geometrical construction of a root by ruler and compass (nothing like this again until 19th century); gave the identity $(a^2+b^2)(c^2+d^2)=(ac\pm bd)^2+(ad\mp bc)^2$.
2. *Chu-Shih-Chieh* (13th century, Chinese): knew (1303) Pascal triangle and binomial expansion for positive integral powers; obtained numerical solution of equations by method not known in Europe until reinvented by Ruffini (1804) and Horner (1819).
3. *Scipione del Ferro* (1465–1526, Italian): solved (1515) the equation $x^3+px=q$ and gave (1535) results to Antonio Fior.
4. *Tartaglia* (1500–1557, Italian): solved (1535) the equation $x^3+px^2=q$ and rediscovered Ferro's solution; knew (1556) Pascal triangle.
5. *Ferrari* (1522–1565, Italian): solved (around 1540) general quartic.
6. *Stifel* (1487–1567, German): published (1544) table similar to Pascal triangle; said negative numbers absurd.
7. *Cardano* (1501–1576, Italian): first to exhibit 3 real roots of cubic, suspected all cubics had 3 roots but baffled by negatives and imaginaries, published solutions (1545) which essentially completely solved cubics and quartics; used (1570) Pascal triangle but missed application to binomial theorem, although may have known the application (this ends period of

Diophantus and Hindu tradition and general principles become more prominent).

8. *Bombelli* (16th century, Italian): recognized (1572) the reality of the roots of a cubic in the irreducible case; consistent use of imaginary numbers showing for example that

$$\sqrt[3]{52+\sqrt{-2209}}=4+\sqrt{-1}$$

(imaginary numbers arose in cubic equations before they were understood in quadratics, not fully accepted until the 19th century).

9. *Vieta* (1540–1603, French): first unmistakable evidence of transtion from the special to the general (1591); used linear transformation to solve quadratics, cubics and quartics; negatives not understood; considered problem of expressing $f(x)=0$ in linear factors (fundamental theorem of algebra proved by Gauss in 1799); fifth degree equation with five roots; important advance with use of letters for both given and unknown numbers (vowels for unknowns and consonants for knowns—A for unknown, A quadratus for A^2, Ac for A^3, Aqq for A^4, etc.); uniform method (like Newton's of 1669) for obtaining numerical solutions of algebraic and transcendental equations; found 23 roots of a 45 degree equation; suggested cubics could be solved trigonometrically, relation between cubic and trisection of an angle shown; foundation for analytics with application of algebra to geometry (next great algebraist was Lagrange).

10. *Stevin* (1548–1620, Dutch): used (1585) exponential notation for integral and fractional exponents in presenting decimal fractions; first to use the quadratic formula in solving quadratics; knew Pascal triangle.

II. The Period After 1600

A. *The Seventeenth Century.*

1. *Harriot* (1560–1621, English): made algebra more analytic, advancing notation and symbolism; rejected negative and imaginary roots; first to use modern symbols for "less than" and "greater than"; improved Vieta's notation for powers by using *aa* instead of *Aq*, etc.; gave binomial coefficients in form of Pascal triangle; solved quadratics by factoring.

2. *Oughtred* (1574–1660, English): text one of most influential in Great Britain in first of 17th century (contributed to laying foundations for Newton); emphasized use of symbols, introduced $\times$ for multiplication, :: for proportion and $\sim$ for difference between; gave Pascal triangle.

3. *Girard* (1590–1633, Dutch): applied extreme formalism to supplying any lack of real roots of an equation by guessing the remaining would be exactly met by complex roots; knew Pascal triangle.
4. *Descartes* (1596–1650, French): modern literal notation with an algebraic equation representing a relation between numbers instead of between lines; modern exponential notation for integral exponents (not for fractional exponents); perfected generalizations begun by Vieta; another solution of quartic; rule of signs on the number of roots of an equation; applications (1637) of algebra to geometry began analytic geometry.
5. *Fermat* (1601–1665, French): master in field of Diophantine analysis; studied Pell's equation; stated (1637) $x^n+y^n=z^n$ has no solution in integers for n greater than 2; cofounder of probability with Pascal; used algebraic methods in geometry.
6. *Pascal* (1623–1662, French): applied Pascal triangle to probability.
7. *Huddle* (1633–1704, Dutch): first (1659) to intentionally use the same letter for both a positive and a negative number.
8. *Gregory* (1638–1675, Scotch): gave (without proof, 1670) a binomial expansion with a fractional exponent.
9. *Wallis* (1616–1703, English): made (1673) an effort to represent an imaginary number graphically; practically made algebra into analysis with imaginary, negative and fractional exponents and with infinite series and infinite products.
10. *Tschirnhausen* (1651–1708, German): generalized (1683) removal of certain terms from equation by the method of substitution.
11. *Newton* (1642–1727, English): extended Descartes' rule of signs; introduced his method for approximating a root; gave method for finding sum of the nth powers of the roots; introduced general literal exponent a^n; used explicit binomial expansions but did not prove the general binomial theorem; classified cubic equations.
12. *Liebniz* (1646–1716, German): gave (1693) rule similar to use of determinants for solution of simultaneous linear equations; generalized binomial theorem to any polynomial to any power; excellent symbolism and notations.

B. *The Eighteenth Century.*

1. *Cramer* (1704–1752, Swiss): amplified (1750) Leibniz' rule of solution of simultaneous linear equations.
2. *Euler* (1707–1783, Swiss): introduced symbol i for imaginary unit, used imaginary exponents; gave (1770) another solution of the quartic; thought general quintic solvable by radicals;

improved numerical solutions of equations; made ambitious attack on diophantine equations but did not get general methods or general theorems; gave (1770) a proof of Fermat's last theorem for $n=3$; gave (1773) first proof of binomial theorem for all real exponents.

3. *D'Alembert* (1717–1783, French): first published proof (incorrect) of fundamental theorem of algebra.
4. *Bezout* (1730–1783, French): simplified (1764) Cramer's rule.
5. *Vandermonde* (1735–1796, French): gave (1771) systematic account of knowledge of what later became known as determinants.
6. *Lagrange* (1736–1813, Italian-French): gave necessary and sufficient conditions for solution in integers of $Cx^2+B=y^2$ (gave method for finding all solutions); gave (1773) theory of binary quadratics as technique for solution of some diophantine problems (a considerable part of diophantine analysis thus became a study of various forms—n-ary quadratics and forms of higher degree—which has been developed by many workers into an independent division of mathematics, a part of the theory of numbers); proved methods for cubic and quartic not adequate for the quintic; attempted to prove fundamental theorem of algebra; gave valid method for finding imaginary roots; discovered identities later recognized as properties of determinants.
7. *Laplace* (1749–1827, French): gave (1772) rule for expansion of a determinant; attempted proof of fundamental theorem of algebra.
8. *Bring* (1736–1798, Swedish): reduced (1786) general quintic to $x^5+ax+b=0$ by the method of transformation.
9. *Wessel* (1745–1818, Norwegian): gave (1797) consistent, useful interpretation of complex numbers that had no effect because it was published in an obscure journal.
10. *Ruffini* (1765–1822, Italian): showed (1799–1813) solution of general equation of degree greater than four not possible by radicals; obtained (1804) equivalent of Horner's method.

C. *The Nineteenth Century.*

1. *Argand* (1768–1822, Swiss-French): independently arrived (1806) at same results as Wessel.
2. *Gauss* (1777–1855, German): gave (1801) first satisfactory proof of fundamental theorem of algebra, showed errors of d'Alembert, Euler, Lagrange and Laplace (modern proof uses methods of Galois); systematized theory of binary quadratics which grew out of diophantian equations; defined algebraic integers; worked on binomial equations $x^n-1=0$; worked on

Fermat's last theorem; got (1831) complex numbers accepted with a treatment as number couples.

3. *Horner* (1773–1827, English): developed (1819) his method of obtaining numerical solutions of equations.
4. *Legendre* (1752–1833, French): proved (1823) the case $n=5$ of Fermat's last theorem in the form $x^n+y^n+z^n=0$.
5. *Abel* (1802–1829, Norwegian): proved (1824), independently of Ruffini, general algebraic equation of degree higher than four is unsolvable by radicals; discovered algebraic numbers which are not expressible by radicals; gave more general treatment of elliptic functions than Gauss; worked on Fermat's last theorem; elaborated general theory of binomial equations; discussed conditions for convergence of general binomial expansion series.
6. *Galois* (1811–1832, French): solved (1830) more general problem than did Gauss, proved necessary and sufficient conditions for solutions by radicals of any algebraic equations (following this, interest in special problems declined if there was a general problem including the special cases that could be considered).
7. *Fourier* (1758–1830, French): published (1831) valuable work on the limit to number of real roots of an equation in any given interval (had been teaching the method for 25 years).
8. *Cauchy* (1789–1857, French): placed (1815) determinants on a firm basis as an independent theory from that of algebraic equations; justified complex numbers with theory of algebraic equivalences; gave condition for binomaial $(1+x)^n$ when x complex; published results on Fermat's last theorem based on assumptions later proved false.
9. *Sturm* (1803–1855, Swiss): gave method determining exact number of roots of an equation in any interval.
10. *Peacock* (1791–1858, English): perceived (1834, 1845) common algebra as an abstract deductive science of the Euclidean pattern.
11. *Lamé* (1795–1870, French): proved (1839) the case $n=7$ of Legendre's form of Fermat's last theorem.
12. *Hamilton* (1805–1865, Irish): introduced (1840) quaternions as three-dimensional extensions of the two-dimensional complex numbers, giving an algebra with $ab=-ba$; independently discovered (1837) the theory of complex numbers given by Gauss; developed (1853) the beginnings of the theory of matrices.
13. *Grassmann* (1809–1877, German): developed (1844) general-

ized n-dimensional complex numbers including quaternions, determinants, matrices and tensors.

14. *Cayley* (1821–1895, English): gave (1843) sketch of n-dimensional geometry independently of Grassmann; introduced (1858) modern concept of matrix with idea it precedes concept of determinant, showed a quaternion can be represented as a matrix (this field rapidly expanded in the hands of many workers to become a field of algebra independent of the solution of equations).
15. *Hermite* (1822–1905, French): showed (1858) Bring's form of quintic (hence the general quintic) could be solved by elliptic functions (analogous to the solution of the general cubic in circular functions).
16. *Hankel* (1814–1899, German): expounded (1867) Peacock's ideas and added more comprehensive form of some of material.
17. *Weierstrass* (1815–1897, German), *Cantor* (1845–1916, German) and *Dedekind* (1831–1916, German) gave in 1860's, 1871 and 1872 respectively, self-consistent theories for the foundation of the real number system; they attempted a unified derivation of real numbers from the natural numbers.
18. *Kronecker* (1823–1891, German): developed (1879–1887) Galois fields, which gives structure for general equation of any degree; objected strongly to treatments of Weierstrass, Dedekind and Cantor and presented a treatment of the number system of his own.
19. *Du Bois-Reymond* (1831–1889, German): delivered (1882) a vigorous attack on formalism.
20. *Frege* (1848–1925, German): gave (1884) first correct logical definition of number.
21. *Hilbert* (1862–1943, German): refined and extended theory of groups; helped establish the postulational method.

D. *The Twentieth Century*. Developments of the Hamilton-Grassmann algebras have led to vector algebras of mechanics and physics, to the calculus of relativity and to the matrix mechanics of quantum theory. Steinitz (1910) and Noether (1920) have given the theory still another direction of development which has been carried on by many others.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison

State Teachers College, Kirksville, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2263. *Proposed by Dwight L. Foster, Florida A and M College.*

If x, y, z be unequal, and if $2a-3y=(z-x)^2/y$ and $2a-3z=(x-y)^2/z$, then show that $2a-3x=(y-z)^2/x$ and $x+y+z=a$.

Solution by Leon Bankoff, Los Angeles, Calif.

The given equations may be written as

$$2ay-3y^2=z^2-2xz+x^2$$
$$2az-3z^2=x^2-2xy+y^2$$

Subtracting the second equation from the first, and factoring,

$$2a(y-z)-3(y^2-z^2)=2x(y-z)-(y^2-z^2)$$

Dividing both sides by $y-z$, we get

$$2a-3(y+z)=2x-(y+z)$$
$$a=x+y+z$$

This identity may now be operated on to show that $2a-3z=(x-z)^2/x$.

$$2a=2y+2(x+z)$$
$$2a-3(x+z)=2y-(x+z)$$

Multiplying each term by $(x-z)$, we get

$$\begin{aligned}2a(x-z)-3(x^2-z^2)&=2y(x-z)-(x^2-z^2)\\&=2xy-2yz-x^2+z^2+(y^2-y^2)\\&=(y^2-2yz+z^2)-(x^2-2xy+y^2)\\&=(y-z)^2-(x-y)^2\end{aligned}$$

But we have given $(x-y)^2=2\,az-3z^2$.
Substituting this value for $(x-y)^2$ in the last equation, we have

$$2a(x-z+z)-3(x^2-z^2+z^2)=(y-z)^2$$

Or,

$$2a-3x=\frac{(y-z)^2}{x}$$

Solutions were offered by: John W. Renner, University of South Dakota; Jean Kolke, Valparaiso University; Nicholas Kushta, Arlington Heights, Ill.; James A. Cochran, Culver, Indiana; A. Mac Neish, Chicago; Hugo Brandt, Chicago; John Q. Taylor King, Austin, Texas; Martin Hirsch, Brooklyn, N. Y.; Francis Sevier, Princeton, New Jersey; and the proposer.

2264. *Proposed by Dwight L. Foster, Florida A and M College.*

Prove that cx^2-ax+b is a common divisor of ax^3-bx^2+c and bx^3-cx+a if it is a divisor of either one of them.

Solution by Francis A. C. Sevier, Princeton, New Jersey

Let

$$(cx^2-ax+b)(px+q)=ax^3-bx^2+c$$

Then

$$cpx^3+(cq-ap)x^2+(bp-aq)x+bq=ax^3-bx^2+c$$

and

$$cp=a, \qquad b=ap-cq, \qquad bp-aq=0, \qquad bq=c.$$

From these four equations we get $b^2=c^2$ and $a^2=2c^2$; also $p=2, q=1$.
Setting

$$(cx^2-ax+b)(p'x+q')=bx^3-cx+a$$

and following the same line of reasoning we find that $b^2=c^2$ and $a^2=2c^2$ in this equation too. However $p'=1$ and $q'=2$. Therefore, we must conclude that the theorem as stated is true since the constants p, q, p', and q' can be determined under constant relationships between a, b, and c.

EDITOR'S NOTE: Others used the "hammer and tongs" method of long division to arrive at the same result. Also a, b, c are not zero.

Other solutions were offered by: Martin Hirsch, Brooklyn: Nicholas Kushta, Arlington Heights, Ill.; and the proposer.

2265. *Proposed by C. W. Trigg, Los Angeles City College.*

Along a straight road a farmer had planned to fence off two equal adjacent square plots of a certain area. He found that the available frontage was two feet short. However, by using two more feet of fencing he was able to fence in two square plots of the desired total area. What were the sides of the plots?

Solution by James F. Gray, Kirkwood, Mo.

The desired plots are two adjacent squares of side x, total area $2x^2$, and requiring a total fence of $7x$.

The plots actually employed are two adjacent squares of sides a and b respectively (let a be the larger), total area a^2+b^2, and requiring total fence of $4a+3b$.

From the given conditions we can write the following:

(1) $$a+b=2x-2$$

(2) $$4a+3b=7x+2$$

(3) $$a^2+b^2=2x^2.$$

Solving (1) and (2) first for a and then for b we obtain:

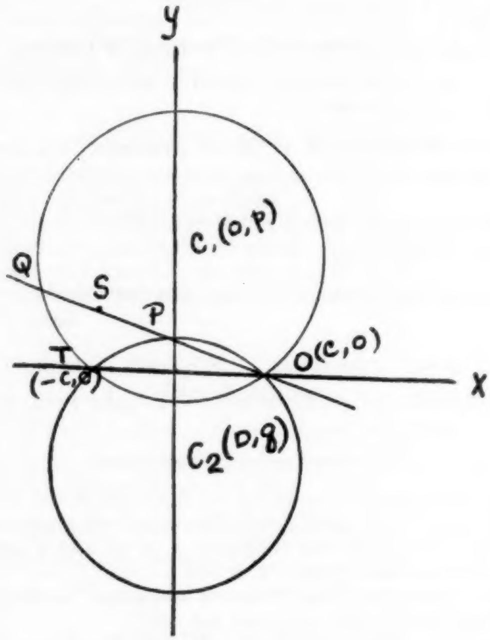
(4) $$a=x+8 \qquad b=x-10.$$

Substituting these in (3) and simplifying, $x=41$, whence $a=49$ and $b=31$, the sides of the final square plots.

Solutions were offered by: Hugo Brandt, Chicago; Herbert A. Smith, University of Nebraska; Emery J. Crane, Mt. Pleasant, Iowa; and the proposer.

2266. *Proposed by Cecil B. Read, Wichita, Kansas.*

PQ is a straight line drawn through 0, one of the common points of two circles, and meets them again is *P* and *Q*; find the locus of the point *S* which bisects the line *PQ*.



Solution by Hugo Brandt, Chicago

Let the y axis contain the centers and the x axis be the common chord. The equations of the 2 circles are

(1) $$x^2+y^2-2py=c^2, \quad \text{radius} \quad \sqrt{c^2+p^2}$$

(2) $$x^2+y^2-2qy=c^2, \quad \text{radius} \quad \sqrt{c^2+q^2}.$$

Let the equation of the family of straight lines through point O be:

(3) $$y=t\left(\frac{x}{c}+1\right)$$

with y intercept, the parameter P.

The abscissa of P, found by eliminating y from (1) and (3) is:

$$X_P=\frac{c}{c^2+t^2}\,(c^2-t^2+2pt)$$

The abscissa of Q is:

$$X_Q=\frac{c}{c^2+t^2}(c^2-t^2+2qt)$$

The abscissa of S, the mid point of PQ is:

$$X_S=\frac{c}{c^2+t^2}\left(c^2-t^2+2\frac{p+q}{2}t\right) \tag{4}$$

Eliminating the parameter t from (3) and (4) yields the required locus of S:

$$x^2+y^2-2\frac{p+q}{c}y=c^2$$

which is a circle.

The proposer points out that a solution appears in Loney's Coordinate Geometry.

2267. *Proposed by Howard D. Grossman, New York.*

The center of gravity of a thin homogenous triangular plate coincides with that of the three equal masses at the vertices of a triangle.

Also show that the center of gravity of a thin homogenous quadrangular plate does not coincide with that of four equal masses at the vertices unless the quadrilateral is a parallelogram.

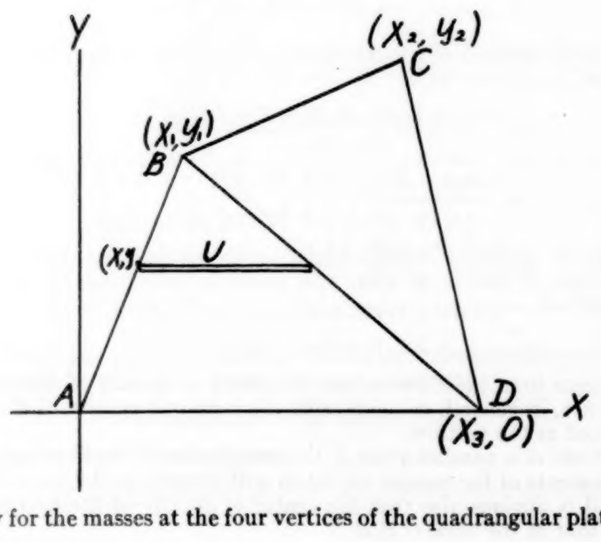
Solution by V. C. Bailey, Evansville College

Without loss of generality the triangular plate ABD and the quadrangular plate $ABCD$ may be taken as shown in the figure. The same figure shows the relative positions of the equal masses.

For the equal masses at the vertices of triangle ABD, we have

$$\bar{x}=\frac{M_y}{3M}=\frac{MX_1+MX_3}{3M}=\frac{X_1+X_3}{3}$$

$$\bar{y}=\frac{M_x}{3M}=\frac{MY_1}{3M}=\frac{Y_1}{3}$$



Similarly for the masses at the four vertices of the quadrangular plate, we have

$$\bar{x}=\frac{M_y}{4M}=\frac{MX_1+MX_2+MX_3}{4M}=\frac{X_1+X_2+X_3}{4}$$

$$\bar{y}=\frac{M_x}{4M}=\frac{MY_1+MY_2}{4M}=\frac{Y_1+Y_2}{4}$$

From similar triangles, as shown in the figure,

$$\frac{U}{X_3}=\frac{Y_1-Y}{Y_1} \quad \text{or} \quad U=\frac{X_3}{Y_1}\,[Y_1-Y.]$$

The area of triangle ABD equals

$$K_1=\frac{X_3Y_1}{2}$$

The area of triangle BCD equals

$$K_2=\frac{X_3Y_2+X_2Y_1-X_3Y_1-X_1Y_2}{2}$$

The equation of line AB is

$$Y=\frac{Y_1}{X_1}\,X.$$

The center of gravity of the triangular area ABD is

$$\bar{x}=\frac{(X+U/2)UdY}{K_1}=\frac{X_1+X_3}{3}$$

$$\bar{y}=\frac{YUdY}{K_1}=\frac{Y_1}{3} \qquad \text{Q.E.D.}$$

Similarly, but not as simply, the center of gravity of the triangular area BCD is found to be

$$\bar{x}=\frac{X_1+X_2+X_3}{3}$$

$$\bar{y}=\frac{Y_1+Y_2}{3}$$

By using the method of composite areas the center of gravity of the quadrilateral, $ABCD$, is found to be

$$\bar{x}=\frac{K_1(X_1+X_3)/3+K_2(X_1+X_2+X_3)/3}{K_1+K_2}$$

$$=\frac{X_1X_2Y_1-X_1^2Y_2+X_2X_3Y_2+X_2^2Y_1-X_1X_2Y_2+X_3^2Y_2}{3(X_3Y_2+X_2Y_1-X_1Y_2)}$$

$$\bar{y}=\frac{K_1Y_1/3+K_2(Y_1+Y_2)/3}{K_1+K_2}$$

$$=\frac{X_2Y_1^2-X_1Y_1Y_2+X_3Y_2^2+X_2Y_1Y_2-X_1Y_2^2}{3(X_3Y_2+X_2Y_1-X_1Y_2)}$$

It is obvious from these forms that the center of gravity of the quadrangular plate does not, in general, coincide with the center of gravity of the four equal masses placed at the vertices.

The centroid of a parallelogram is the intersection of its diagonals.

If the moments of the masses are taken with respect to the intersection of the diagonals, it is obvious also that the center of gravity of the four masses coincides with that of the area. *Q.E.D.*

A solution was also offered by Hugo Brandt, Chicago.

2268. *Proposed by Alan Wayne, Flushing, N. Y.*

In triangle ABC prove that the maximum value of

$$(\sin A+\sin B+\sin C)(\cos A+\cos B+\cos C)=9\sqrt{3}/4$$

Solution by Leon Bankoff, Los Angeles, Calif.

$$\begin{aligned}
&(\sin A+\sin B+\sin C)(\cos A+\cos B+\cos C)\\
&\quad=(\sin A\cos B+\sin B\cos A)+(\sin A\cos C+\sin C\cos A)\\
&\qquad+(\sin B\cos C+\sin C\cos B)+\sin A\cos A+\sin B\cos B+\sin C\cos C\\
&\quad=\sin(A+B)+\sin(A+C)+\sin(B+C)+\sin A\cos A+\sin B\cos B+\sin C\cos C\\
&\quad=\sin C+\sin B+\sin A+\sin A\cos A+\sin B\cos B+\sin C\cos C \qquad (1)\\
&\quad=\sin A(1+\cos A)+\sin B(1+\cos B)+\sin C(1+\cos C)
\end{aligned}$$

On the right side of this identity, each of the three terms may be maximized separately, for the variable in each term has been expressed in terms of the other two variables. For instance, in (1), $\sin C$ has been substituted for $\sin(A+B)$, $\sin B$ for $\sin(A+C)$, and $\sin A$ for $\sin(B+C)$. By differentiating each term with respect to its own variable, equating to zero and solving, we find that $A=B=C=60°$ yields a maximum for each term and hence for the sum. Thus:

$$\begin{aligned}
\frac{d[\sin A(1+\cos A)]}{dA}&=\cos A(1+\cos A)-\sin^2 A\\
&=\cos A+\cos^2 A-\sin^2 A\\
&=\cos A+(1-\sin^2 A)-\sin^2 A\\
&=(\cos A+1)-2\sin^2 A\\
&=2\cos^2(A/2)-2\sin^2 A
\end{aligned}$$

Equating to zero and solving for A:

$$\begin{aligned}
2\cos^2(A/2)&=2\sin^2 A\\
\cos(A/2)&=\sin A \quad \text{(neglecting negative values)}\\
\sin(90°-A/2)&=\sin A\\
A&=60° \quad \text{(maximum because } f''(A) \text{ is negative)}
\end{aligned}$$

Similarly $B=60°$ and $C=60°$ yield maximum values for the other two terms. Substituting for A, B, and C in the original expression,

$$(3\sin 60°)(3\cos 60°)=9\sqrt{3}/4$$

Other solutions offered by: James F. Gray, Kirkwood, Mo.; Hugo Brandt, Chicago.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

PROBLEMS FOR SOLUTION

2281. *Proposed by Hugo Brandt, Chicago.*

Show that tangents to the curve $x^2+y^2=x^3$ cannot have a slope between $\sqrt{3}$ and $-\sqrt{3}$.

2282. *Proposed by Hugo Brandt, Chicago.*

Adopting the notation for a recurring continuous fraction

$$a+\frac{1}{b+}\left[\frac{1}{c+}\left[\frac{1}{d+}\cdots\right.\right.$$

for the older more cumbersome notation:

$$a+\cfrac{1}{b+\cfrac{1}{c+}\cdots}$$

develop $\sqrt{19}$ into such a fraction.

2283. *Proposed by C. W. Trigg, Los Angeles City College.*

An arithmetic progression and its reverse are multiplied term by term. Find a general expression for the sum of the products. An example:

$$3\cdot 11+5\cdot 9+7\cdot 7+9\cdot 5+11\cdot 3=205$$

2284. *Proposed by Roy Wild, University of Idaho.*

Show that

$$\sqrt[4]{\frac{3+2\sqrt[4]{5}}{3-2\sqrt[4]{5}}}=\frac{\sqrt[4]{5}+1}{\sqrt[4]{5}-1}$$

2285. *Proposed by Charles McCracken, Jr., University of Cincinnati.*

Evaluate:

$$\lim_{n\to\infty}\frac{2n}{Csc\,\dfrac{\pi}{n}}$$

2286. *Proposed by Charles McCracken, Jr., University of Cincinnati.*

Show that if p is any prime, and p^2 is divided by 12 the remainder is 1.

HEATING OF LEAD USED TO MEASURE X-RAY ENERGY

A "hot lead" technique can now be used to measure X-ray energy in terms of standard heat measurements of energy instead of by indirect measurements through secondary phenomena.

The method, worked out by University of Illinois physicists, measures the rays' heating effects on a block of lead. The method gives very precise measurements and can be used on X-rays of energies from the 400,000 used in conventional medical X-ray treatments, to the 340,000,000 volts from the University's betatron.

Though the physicists term the new method a "hot lead" technique, the actual temperature rise is no more than one-tenth of a degree. The small temperature increases are measured by a thermistor, a new type of heat-measuring device 10 times as sensitive as older resistance thermometers. It is embedded in the lead.

University of Illinois physicists here and at the medical campus in Chicago worked together on the new development. P. D. Edwards in the betatron laboratory here worked in the 300,000,000-volt range, and J. S. Laughlin at the College of Medicine at the 25,000,000 and 400,000-volt levels.

BOOKS AND PAMPHLETS RECEIVED

THE MOLDS AND MAN, AN INTRODUCTION TO THE FUNGI, by Clyde M. Christensen, Professor of Plant Pathology. *University of Minnesota.* Cloth. Pages viii+244. 14×22 cm. 1951. University of Minnesota Press, Minneapolis 14, Minn. Price $3.00.

INTERMEDIATE ALGEBRA FOR COLLEGES, by Joseph B. Rosenbach, *Professor of Mathematics and Head of the Department,* and Edwin A. Whitman, *Associate Professor of Mathematics, Carnegie Institute of Technology.* Cloth. Pages x+219 +xxii. 13×21 cm. 1951. Ginn and Company, Statler Building, Boston, Mass. Price $3.00.

SPINOZA DICTIONARY, Edited by Dagobert D. Runes, *Doctor of Philosophy of the University of Vienna.* Cloth. Pages xiv+309. 13.5×21.5 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $5.00.

TENSOR ANALYSIS, THEORY AND APPLICATIONS, by I. S. Sokolnikoff, *Professor of Mathematics, University of California, Los Angeles.* Cloth. Pages ix+335. 14.5×23 cm. 1951. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.00.

FINITE MATRICES, by W. L. Ferrar, M.A., D.Sc., *Fellow of Hertford College, Oxford, England.* Cloth. Pages v+182. 13.5×22 cm. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $4.00.

ASTRONOMY OF STELLAR ENERGY AND DECAY, by Martin Johnson, *Doctor of Science, Fellow of the Royal Astronomical Society and of the Institute of Physics.* Cloth. 216 pages. 13.5×22 cm. Dover Publication, Inc., 1780 Broadway, New York 19, N. Y. Price $3.50.

CALCULUS, Revised Edition, by Joseph Vance McKelvey, *Professor of Mathematics, Iowa State College, Ames, Iowa.* Cloth. Pages vii+405. 13.5×21 cm. 1951. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.50.

CAREERS IN PHYSICS, by Alpheus W. Smith, *Professor of Physics, Emeritus, and Dean Emeritus of the Graduate School, The Ohio State University.* Cloth. 271 pages. 15×23 cm. 1951. Long's College Book Company, 1836 North High Street, Columbus 1, Ohio. Price $4.00.

AN INTRODUCTION TO ACOUSTICS, by Robert H. Randall, *Associate Professor of Physics, The City College of New York.* Cloth. Pages xii+340. 15×23 cm. 1951. Addison-Wesley Press, Inc., Cambridge 42, Mass. Price $6.00.

THE ALGEBRA OF VECTORS AND MATRICES, by Thomas L. Wade, *Florida State University.* Cloth. Pages ix+189. 13.5×21.5 cm. 1951. Addison-Wesley Press, Inc., Cambridge 42, Mass. Price $4.50.

CALCULUS AND ANALYTIC GEOMETRY, by George B. Thomas, Jr., *Associate Professor of Mathematics, Massachusetts Institute of Technology.* Cloth. 693 pages. 15×23 cm. 1951. Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. Price $6.00.

FUNDAMENTALS OF ELECTRONICS, by F. H. Mitchell, *Professor of Physics, University of Alabama.* Cloth. Pages xi+243. 15×23 cm. 1951. Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. Price $4.50.

TV AND ELECTRONICS AS A CAREER, by Ira Kamen, *Brach Mfg. Corporation,* and Richard H. Dorf, *TV Consultant.* Cloth. Pages x+326. 1951. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $4.95.

PHILOSOPHICAL PROBLEMS OF MATHEMATICS, by Bruno Baron v. Freytag, *Lecturer on Philosophy, University of Tübingen.* Translated from the German by

Amethe Countess von Zeppelin. Cloth. 88 pages. 13.5×21 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $2.75.

BRITISH SCIENTISTS, by E. J. Holmyard, M.A., M.Sc., D.Litt., F.R.I.C., *Editor of Endeavour.* Cloth. Pages viii+88. 18.5×12 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $2.75.

HOW TO STUDY, HOW TO SOLVE—ARITHMETIC THROUGH CALCULUS, by H. M. Dadourian, *Seabury Professor of Mathematics and Natural Philosophy (Emeritus), Trinity College.* Paper. Pages vi+121. 11.5×17 cm. 1951. Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. Price $1.00.

A LABORATORY COURSE IN BIOLOGY, by James C. Adell, *Chief Bureau of Educational Research, Cleveland Public Schools,* and Louis E. Welton, *Formerly Head of the Science Department, Assistant Principal, John Hay High School, Cleveland, Ohio.* Paper. Pages vi+282. 18.5×26.5 cm. 1951. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.20.

PROBLEM BOOK FOR GENERAL CHEMISTRY, by Royce H. LeRoy, *Professor of Chemistry, A. and M. College of Texas.* Paper. Pages v+170. 20.5×28 cm. 1951. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $1.90.

EDUCATION UNLIMITED, A COMMUNITY HIGH SCHOOL IN ACTION, by Grace S. Wright and Walter H. Gaumnitz, *Division of Elementary and Secondary Schools,* and Everett A. McDonald, Jr., *East Hampton High School, East Hampton, Conn.* Bulletin 1951, No. 5. Pages iv+35. 15×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

GEWOHNLICHE DIFFERENTIALGLEICHUNGEN, by Prof. Dr. Guido Hoheisel, *Professor der Mathematik an der Universitat Koln.* Paper. Pages 129. 10.5×15.5 cm. 1951. Walter de Gruyter & Co., Berlin, Germany.

HOW CHILDREN USE ARITHMETIC*

EFFIE G. BATHURST

This is another in a series of bulletins on the place of subjects in the elementary school curriculum. The first of the series showed how subject matter is introduced into the program in a modern school, and was titled *The Place of Subjects in the Curriculum,* Office of Education Bulletin 1949, No. 12 (15 cents). Another in the series already issued is *How Children Learn to Think,* Office of Education Bulletin 1951, No. 10 (15 cents). Other bulletins planned for the series will discuss how other skills are developed in the modern school program.

This bulletin shows how children develop arithmetic abilities. It gives an overview of some of the problems in teaching with which the modern teacher deals as she helps her pupils to understand and use number concepts effectively. It illustrates ways in which boys and girls are helped to enrich each day's experiences through arithmetic and to make the subject consciously a part of life.

* Office of Education Bulletin 1951, No. 7. 13 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 15 cents.

BOOK REVIEWS

EMBRYOLOGY OF THE VIVIPAROUS INSECTS, by Harold R. Hagan, *Associate Professor of Biology, The City College of the College of the City of New York.* Cloth. Pages xiv+472. 15×22.5 cm. First Edition. 1951. The Ronald Press Company, New York. Price $6.50.

Awarded the A. Cressy Morrison Prize by the New York Academy of Sciences, Dr. Hagan's new book is the first to present a comprehensive assemblage of the embryology of viviparous insects. This is a highly technical book and, as such, a highly valuable book for research workers in the field of entomology and embryology. In addition to its presentation of a historical bibliography, there is a considerable amount of new research included, and the author also appraises and evaluates the gaps and inadequacies in the field. This is definitely a pioneering endeavor, the appreciation of which will increase with the years and subsequent editions.

GEORGE S. FICHTER
Oxford, Ohio

THE HOUSE OF LIFE, by George A. Rubissow. Cloth. 15.5×23.5 cm. Pages 381. First Edition. 1951. Ricardo Press, New York. Price $4.00.

The House of Life is a different book, filled with facts presented in a strangely dramatic, nearly unrealistic manner—with a confusing twist and yet a startling clarity. Mr. Rubissow believes our world is a difficult one in which to live. It is "both too big and too small, too rich and too poor, too fast and too slow." There is such a mass of accumulated knowledge that Mr. Average Man is lost in its midst, unable to comprehend the whole for the swarm ot uncorrelated parts. Mr. Rubissow wrote his book for youth so that they might salvage their lives from these whirlpools and undercurrents which both "create and kill." It is a book which spans many subjects, picking from each a "guidepost" for the path of life which runs toward the gate of truth. If the book accomplishes no more, it makes every reader begin to think for himself and to appraise his surroundings. Even if he disagrees violently with Mr. Rubissow, he is at least forced from his mental lethargy.

GEORGE S. FICHTER

ELEMENTARY SCIENCE EDUCATION IN AMERICAN PUBLIC SCHOOLS, by Harrington Wells, *Associate Professor of Science Education, University of California, Santa Barbara College.* Cloth. Pages ix+333. 15×23 cm. 1951. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $3.75.

Elementary Science Education is a textbook concerned with the methods of teaching science in the elementary school. It is designed to serve a dual purpose; as a text for elementary school methods classes in teacher training institutions, and for use by teachers-in-service, principals and supervisors.

Part I is devoted to theory and practice in the teaching of science. The author stresses the formulation of a philosophy of science teaching based upon the belief that the child is an integrated developing individual. This leads to a discussion of the type of academic training that appears desirable for elementary teachers: namely the survey type of college courses.

Although many references are made to the desirability of including some physical science in the elementary curriculum emphasis is placed upon the biological science offerings below the junior high school level. Nature study is recommended as the science in the primary grades. In the discussion of this phase of the science program Prof. Wells places his stamp of approval on the employment of fairy tales and anthropomorphism in the teaching of science but that this should not be carried to the extreme. It is believed that as the child matures he may be helped to distinguish between fact and fancy.

Science as a separate subject in the curriculum is mentioned and condoned

provided the teacher is effective in utilizing this method, however, the social studies—science correlation or integration method is strongly recommended. Prof. Wells states "Social awareness is a primary requisite for successfully vitalized science education in the world of tomorrow."

Part II is devoted to resource aids. These aids are listed as: audio visual sources of supply, bibliography for teachers, sources of booklets, pamphlets etc., conservation agencies, playlets, songs, readers, recordings, magazines, workbooks, and supplies and apparatus.

MILTON O. PELLA
Assistant Professor of Education
University of Wisconsin

LINEAR COMPUTATIONS, by Paul S. Dwyer, *Professor of Mathematics, University of Michigan.* Cloth. Pages xi+344. 15×23.5 cm. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $6.50.

No doubt many teachers of high school or college algebra might wonder how anyone could write a book of over three hundred pages devoted almost entirely to the solution of simultaneous linear equations. There is indeed much more material in this book, but as the title indicates, this is the main objective. If, however, one considers the problem of solving a problem involving perhaps a dozen equations in a dozen unknowns, the need for systematic methods and the use of modern calculating machines becomes very evident.

The methods presented are planned for the individual worker who has access to one of the modern desk calculators, rather than a large electronic machine. The material is not restricted to any particular make or model of machine, but assumes a machine which is equipped to carry out multiplication and division rapidly, preferably a fully automatic machine.

There is an unusually good treatment of computation with approximate numbers; the author likewise makes clear distinction between exact and approximate solutions, as well as between exact and approximate problems. In discussing operations involving exact methods, continual emphasis is placed upon the importance of delaying approximate operations (division or extraction of roots) as long as possible. In many cases it is shown how formulas customarily used fail to take this into account, with the possible cumulation of errors.

The methods used are first presented in terms of elementary algebra—although a reader rusty in mathematics might be disturbed by the notation, actually there is essentially nothing beyond high school algebra in the first eight chapters. The advantages of various methods are discussed, and means of checking are emphasized. In the ninth through the eleventh chapters the reader is introduced to determinants and their evaluation. There is no attempt to derive theory, but rather emphasis is placed upon properties of determinants and methods for their evaluation. The reader familiar with only the classical methods usually presented in algebra texts will be surprised at the advantages of other methods. At approximately the middle of the book, the reader is introduced to the algebra of matrices, and methods are given for the calculation of the adjoint and the inverse, with many applications.

Anyone who has done work in the field of statistics will realize the need for a text such as this. There are many fields, however, other than statistics in which there is occasion for the solution of simultaneous linear equations, and the author has wisely selected to use a general mathematical presentation, although in many cases it seems the treatment arose from a statistical problem. There is considerable discussion of the situation where the coefficients of the equations are subject to error; there is a brief discussion of the application of the methods to non-linear problems.

Many of the chapters have a list of illustrative exercises at the end—no answers are printed. There are supplementary references given in almost every chapter.

For anyone having occasion to deal with material of the type covered, this

book is almost unique—it would take a good deal of searching in a library to find even a portion of the subject matter. Even then one would be likely to encounter a single method rather than several alternatives. The book could well be used as a supplementary text in courses in applied statistics; it should be in the library of any college offering work beyond the elementary level in the field of statistics.

CECIL B. READ
University of Wichita

THE CALCULUS OF FINITE DIFFERENCES, by L. M. Milne-Thomson, *Professor of Mathematics in the Royal Naval College, Greenwich Gresham Professor in Geometry*. Cloth. Pages xxiii+558. 14×22 cm. 1951. Macmillan and Company, Limited, St. Martin's Street, London. Price $4.50.

This is a 1951 reprinting of the first edition of this classic text, the first edition having appeared in 1943. For some time the book has not been available except in second-hand stores. There is no evidence of any change since the first edition. The material is rather traditional. In order to follow the treatment one must have a knowledge of such mathematical concepts, for example, as determinants, integral calculus, Fourier series, complex variable theory. Even if one does not care to follow all the treatment in the book, there are certain portions which would be of considerable value as an extension of, for example, certain topics in calculus, such as numerical differentiation and integration. There is some excellent treatment of interpolation. For those interested in a more extensive review than space permits here, it is suggested that one might consult the *American Mathematical Monthly*, volume 42, page 240 ff., April, 1935. This book has appeared on several check lists as a very important one to have in a university or college library.

CECIL B. READ

ANALYTIC GEOMETRY, Second Edition, by John W. Cell, *Professor of Mathematics, North Carolina State College of Agriculture and Engineering, University of North Carolina*. Cloth. Pages xii+326. 13.5×21.5 cm. 1951. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.75.

This text is definitely not written for a brief or short course in analytic geometry. The material covered is ample to provide work for a five hour, one semester course. Although some of the material might be omitted, it would be almost impossible to reduce the content to let us say a half of this amount without running into some difficulty. The treatment might be called somewhat traditional, however, the author appeals much more to reasoning processes than to rote memorization of formulas. There is an ample supply of problems, and answers are given to a considerable number of these—approximately half. The answers, however, are not in any specified order, that is, for example the answers to the odd numbered problems that are provided. Moreover, in many cases the author gives what he calls a partial answer which is enough to give the student a clue whether or not he is on the right track, but is likely to stop the practice of "working toward the answer."

There are many refreshing features. For example, there is a very interesting preface both addressed to the student and another addressed to the teacher. There is an interesting example on page 33 showing the necessity of choosing two different general points in discussing a locus. The discussion on page 62 about the choice of scales on the two axes is very good as is also the discussion of change of scale on page 133. The treatment of the sketching of polar coordinate curves is better than is found in many texts as is also true with the discussion of the sketching of parametric equations. The student should be interested in the discussion of the terminology used in naming the quadric surfaces, and the student should also find exceptionally valuable the general review outline occupying three pages.

An appendix summarizes basic material from previous courses. Tables include a four place table of both common and natural logarithms, sines, cosines, tan-

gents, and cotangents; and of exponentials.

In the opinion of the reviewer this is one of the best texts that has appeared on the market in the last few years. By all means anyone wishing a course of this length must consider this as a possible text.

CECIL B. READ

GENERAL HOMOGENEOUS COORDINATES IN SPACE OF THREE DIMENSIONS, by E. A. Maxwell, *Fellow of Queens', College, Cambridge.* Cloth. Pages xiv+169. 13.5×22 cm. Cambridge University Press, American Branch, 51 Madison Avenue, New York 10, N. Y. Price $2.75.

The author's purpose, in his own words, is, "to provide a *short* introduction to algebraic geometry in space of three dimensions, to make clear its spirit, and to prepare the way for deeper study." He assumes as background a knowledge of his work on homogeneous coordinates in a plane or equivalent material, and that the individual is in his second year work at the university. This standard of development at the second year is greater than is found in many American colleges.

The treatment in the earlier portion of the book introduces the student to space of three dimensions treating it from the general idea of projective geometry. As a random sample of topics which are covered one might mention duality, cross ratio, Desargues Theorem, generators of quadric surfaces, poles and polars, elementary systems of quadrics. Following this somewhat general treatment there is a chapter of applications of projective geometry to Euclidean geometry. Starting with the last chapter (and taking up approximately one-sixth of the book) the author introduces the idea of matrices and then applies this new theory to concepts previously treated. There are a number of examples, probably sufficient for the purposes of this book. This is probably better suited as a reference book than as a text in most American colleges. It does have the distinct advantage that both student and teacher are more likely to find something in this brief treatment than in a more exhaustive treatise.

CECIL B. READ

SCIENCE FOR EVERYDAY USE, by Victor C. Smith, *Department of General Science, Ramsey Junior High School, Minneapolis,* and B. B. Vance, *Chairman, Science Department, Kiser High School, Assistant Professor of Biology and Education, The University of Dayton.* In consultation with W. R. Teeters, Director of Education, St. Louis Public Schools. 721 pages. J. B. Lippincott 1951.

In recent years there has been a fruitful abundance of good books for general science on the grammar school, junior high school, and high school levels. The competition in this quarter, as in nearly every textbook quarter, makes for better and better books, so that there is much good in the making of more books! This is another good one built around six major units: Matter, Energy, Life, Earth, Man, Inventions, and designed by exposition and temper for 8th or 9th graders.

The text is sound and pleasantly written. It reads with ease for the level intended. It is well illustrated by photographs and diagrams. Demonstrations are described and Study Tests appear frequently. "Thought Questions" review the chapters. "Some Interesting Books to Read" is a valuable feature since school kids today read far too little. There are several excellent full-page color plates.

Students ought to get a good deal out of this book and if the teachers do all the authors suggest they will have provided an abundantly full schooling in this quarter. The book is sure to meet with success.

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

CLIMATE IN EVERYDAY LIFE, by C. E. P. Brooks, I.S.O., D.Sc., F. R. Met. Soc. 314 pages. Philosophical Library, 1951. $4.75.

Apart from the eminently useful and working knowledge to be gotten from

this book (to distinguish this kind of knowledge from the purely academic!) it is very informative on a number of rare bits of knowledge, and on this score attractive to read. (For example: in a desert region, would you expect the sand or the solid rock to get the hotter?).

This volume reminds me of Huntington's *Civilization and Climate.* Human life in all its aspects is directly affected by climate and weather and unlike Mark Twain this author proposes devices for making the best of the conditions which beset us. If one finds himself a victim of climatic conditions he can, in many cases, improve his living—housing, lighting, clothing, transport, etc.

The book is in three parts: Part I, *Living with the Climate,* which describes types of climate, their effect on various public services, and how to site and design houses and factories to suit weather conditions; Part II, *Climate as an Enemy,* in three sections—one on the effect of heat and humidity on manufactured goods, one on the smoke evil, and one on the accident of various types of storm; Part III, *The Control of Climate,* discusses heating and air-conditioning, clothing and various artificial weather controls.

It is indeed a very informative book. Tables and charts and graphs are abundant. A goodly bibliography is named.

In recent years considerable attention has been given by business men to the effect of weather (present and predicted) and to long-range climate upon their enterprises. *Where a thing is made* is dictated by climate. Special products require special conditions. Large and rapid changes in temperature affect the production of many items, e.g., paint, varnish, textiles. Humidity affects printing. If it is too wet the size of the paper changes and there is loss of accuracy in color work. If it is too dry static electricity is a troublesome feature. Machine-making must be in dust-free regions.

The seasonal distribution and variability of rainfall and the risk of drought dictate agricultural pursuits. Dwellers on river banks are concerned with floods.

In short, man cannot escape the elements! He can, however, make sensible efforts toward improving his forced association with them.

This book is excellent to read.

Julius Sumner Miller

Vacuum-Tube Voltmeters, by John F. Rider; 422 pages. 2nd Edition. John F. Rider Publisher, Inc. 480 Canal Street, New York 13. $4.50.

This is a formidable source book devoted exclusively to vacuum tube voltmeters. Since the birth of this instrument at the turn of the century (those years gave birth to a wilderness of things!) a fantastic array of VTVM has appeared with design for meeting every conceivable circuit arrangement and frequency.

The first edition (1941) was a classical handbook for engineer, student, and serviceman; this second edition embraces ten years of stupendous engineering advance in the subject. The book is essentially practical in its intent but good also for theoretical study. Review Questions at the end of each chapter give the volume a textbook complexion.

The exposition is unassailably sound and straightforward and the circuit diagrams (with but few exceptions) are crystal-clear. A bibliography of some 200 references from world literature is priceless for workers in this field.

This volume belongs on the shelf above the workbench.

Julius Sumner Miller

A New Theory of Gravitation, by Dr. Jakob Mandelker, *Assistant Professor of Mechanics, Georgia Institute of Technology.* 25 pages. Philosophical Library. 1951. $2.75.

In an earlier review in this journal (April 1950) I discussed *Principles of a New Energy Mechanics* by Jakob Mandelker. That monograph presented a thesis possessing very substantial novelty but apparently eminently logical. I again recommend its study.

In this new monograph, *A New Theory of Gravitation*, the author again develops a novel point of view and I am again taken by the apparent soundness of the thesis. The problem classically is this: all forces in Nature possess bipolar property, that is, they evidence themselves ***in pairs***, (e. g., attraction and repulsion, action and reaction). Indeed, as physics students are taught, no force exists alone; all forces exist in pairs. This notion has one flagrant exception, however, and this exception is ***gravitation. The correlative force of repulsion does not exist*** We never find gravitational repulsion.

The ancient and classical question of why does a stone fall to ground—a yet unsolved dilemma—is again before us.

The author's fundamental idea (Chapter I) is stated thus: ". . . the outwardly directed radiational force of matter-energy is coordinated as the counterforce to the inwardly directed force of gravitation." The development of this idea is intriguing and is done in about 20 small pages of very readable text, in chapters entitled:

I. The Exposition of the Basic Idea
II. The Concept of the Radiating Mass Density
III. The Relation Between Matter-Energy and Gravitation; Theoretical Derivation of the Gravitational Constant
IV. Gravitation, Radiation, and Atomic Dimensions
V. The Critical Value of Gravitation; The Electron-Mass as the Quantum of Radiating Matter
VI. The Natural System of Physical Units; The Possibility of a New World Conception

The monograph can be read in a sitting and it is definitely stimulating. It would constitute an elegant colloquium session. I do not, at this writing, have a point of view as to the acceptability of the thesis, but I seriously recommend its reading. It is a classical feature of *new* ideas that proper measure of their worth is not only difficult but dangerous! We may hear more of the idea this author presents.

JULIUS SUMNER MILLER

BASIN BECOMES TEST TUBE FOR STUDYING PEOPLE

The Papaloapan Basin, 300 miles southeast of Mexico City, is serving as a "test tube" to study the reactions of a peaceful, primitive people suddenly thrown into a world of machines and technology.

So reports Dr. Ralph L. Beals, professor of anthropology at the University of California at Los Angeles, who recently returned from the area.

The Mazatec Indians, who occupy part of the Papaloapan Basin, are extremely primitive natives. They still practice many prehistoric ceremonies, such as sacrifices and dances to the gods.

Not long ago the Mexican government began building roads, flood control projects and power dams on their land. Lakes backed up by the dams will soon force many of the Mazatecs to find new homes, while results of the modernization will give them cheap power, transportation and schools.

The 90,000 Mazatec Indians are beginning to react to this progress. Dr. Beals, together with U.C.L.A. graduate student, Ilias Adis Castro, who is currently living with the Indians, are watching this reaction carefully in hopes of uncovering ways and means of easing the change.

"In the Mazatec situation we have a compact, test tube case," Dr. Beals said. "The whole world is undergoing a rapid change through industrialization. Perhaps the Mazatecs can give us some clues on how to keep civilizations from going to pieces under pressures of technological changes."